Stock assessment of Aleutian Islands Region Pollock

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Executive Summary

Development of a detailed age-structured stock assessment for the Aleutian Islands Region pollock began in 2003 (Barbeaux et al. 2003). In this initial study the near shore areas of the Aleutian chain island were isolated and identified as the Near, Rat, and Andreanof Island (NRA) sub-area. This sub-area was further refined to exclude the area east of 174°W to address data consistency issues. The Council supported this proposal and urged continuing development on an age-structured assessment model using data from the area west of 174°W (and omitting deep-water areas where survey data are unavailable).

Pollock fishery data collected near the eastern boundary of the Aleutian Islands region (between of 174°W and 170°W) highlight stock structure uncertainty between the Aleutian Islands region, the Aleutian Islands Basin, and the EBS. Consequently, they are excluded from all of the age-structured assessment models presented below. We do, however, recognize that fluctuations in biomass observed from the summer Aleutian Islands bottom trawl (AIBT) survey data from this area are not clear cut patterns and that substantial uncertainty in the stock structure exists. We therefore have included a model configuration which includes all of the AIBT survey data including that from the eastern NRA area (NRA area east of 174°W).

Spatial analyses of fishery, survey, and bycatch data using GIS methods reveal an important characteristic of pollock in the Aleutian Islands region: concentrations are highly variable and likely evolve quickly within seasons. These analyses underscore the challenge of evaluating stocks that: are highly mobile, spend variable time associated with the bottom, have patchy distributions, and are likely influenced by neighboring stocks.

Summary of major changes

The model configuration does not differ significantly from the 2004 assessment. The data for this year's assessment differ from last year in that age data from the 2004 bottom trawl survey became available. Although the pollock fishery was opened in the Aleutian Islands area with a TAC of 19,000t in 2005, only 200t were removed in the directed fishery and insufficient length and age data were collected to include in the models. .

Changes in the assessment results

The authors recommend as per the 2004 plan team recommendation the long-term expected yield ($F_{40\%}$) under Model 2 which is 41,650 mt and an OFL of 44,860 mt. The recommended harvest strategy would be conservative and is aimed towards maintaining a precautionary approach in the management of the newly developing Aleutian Islands pollock fishery. We believe the maximum allowable ABC under Model 2 would not be adequately risk averse given the early 1990's catch history, the high degree of uncertainty in the 2002 and 2004 AIBT estimate, and the lack of significant fisheries data since 1998.

Response to SSC 2004 Comments

The authors would like to thank the SSC for their comments to the 2004 assessment. Since no new research has been conducted that would help reduce the uncertainties in the stock structure and geographic distribution of the Aleutian Islands pollock stock, the authors understand that the SSC will continue to recommend a Tier 5 approach to setting the 2006 ABC. The authors will continue to improve and present the age-structured model

results because the authors feel the model provides the best means of integrating all the available data, not only survey data, but also fishery, and general biological data as well. Since it is recognized that the summer survey is highly variable and may not provide a consistent index of abundance for pollock in the Aleutian Islands region, the authors recommend that the age-structured model be used to set ABC since it provides a means of utilizing all of the available data to produce an estimate of the stocks potential productivity.

The authors agree with the SSC that catchability (q) can not be estimated given our current lack of understanding of the pollock stock dynamics in the Aleutian Islands area. Figure 24 of the 2004 assessment was meant to demonstrate this point with an unstable and decreasing q value as the MCMC run progressed. Attempting different starting points and longer chains made no difference to the end result, the chains remained unstable and estimates of q were not attainable. Since no new information has come to light since last year, in this assessment as a conservative measure we have set $q = 1.0$ in all of our models.

Introduction

Walleye pollock (*Theragra chalcogramma*) are distributed throughout the Aleutian Islands with concentrations in areas and depths dependent on season. Generally, larger pollock occur in spawning aggregations during February – April. Three stocks of pollock inhabiting three regions in the Bering Sea – Aleutian Islands (BSAI) are identified in the U.S. portion of the BSAI for management purposes. These stocks are: the eastern Bering Sea pollock occupying the eastern Bering Sea shelf from Unimak Pass to the U.S.-Russia Convention line; the Aleutian Islands Region pollock encompassing the Aleutian Islands shelf region from 170°W to the U.S.-Russia Convention line; and the Central Bering Sea—Bogoslof Island pollock. These three management stocks probably have some degree of exchange. The Central Bering Sea—Bogoslof stock is a group that forms a distinct spawning aggregation that has some connection with the deep water region of the Aleutian Basin. In the Russian Exclusive Economic Zone (EEZ), pollock are thought to form two stocks, a western Bering Sea stock centered in the Gulf of Olyutorski, and a northern stock located along the Navarin shelf from 171°E to the U.S.-Russia Convention line. The northern stock is believed to be a mixture of eastern and western Bering Sea pollock with the former predominant. Bailey et al. (1999) present a thorough review of population structure of pollock throughout the north Pacific region. Recent genetic studies using mitochondrial DNA methods have found the largest differences to be between pollock from the eastern and western sides of the north Pacific.

Previously, Ianelli et al. (1997) developed a model for Aleutian Islands pollock and concluded that the spatial overlap and the nature of the fisheries precluded a clearly defined “stock” since much of the catch was removed very close to the eastern edge of the region and appeared continuous with catch further to the east. In some years a large portion of the pollock removed in the Aleutian Islands Region was from deep-water regions and appeared to be most aptly assigned as “Basin” pollock. This problem was confirmed in the 2003 Aleutian Islands pollock stock assessment (Barbeaux et al. 2003).

Fishery

The nature of the pollock fishery in the Aleutian Islands Region has varied considerably since 1977 due to changes in the fleet makeup and in regulations. During the late 1970s through the 1980s the fishing fleet was primarily foreign. In 1989, the domestic fleet began operating in earnest and continued in the Aleutian Islands Region until 1999 when the North Pacific Fishery Management Council (NPFMC) recommended closing this region for directed pollock fishing due to concerns for Steller sea lion recovery. Table 1 provides a history of ABC, OFL, and catch for Aleutian Islands pollock since 1991. In 2005 the fishery was reopened with a 19,000mt TAC. A directed pollock fishery was conducted in February 2005, but the vessels participating in the fishery failed to find commercially harvestable quantities outside of Steller sea lion critical habitat closure areas and removed less than 200mt of pollock. In addition, bycatch rates of Pacific Ocean perch were prohibitively high in areas where pollock aggregations were observed. The 2005 fishery is thought to have resulted in a net loss of revenue for participating vessels. Data on specific bycatch and discard rates for this fishery are not available due to issues of data confidentiality.

Data

Catch estimates

Estimates of pollock catch in the Aleutian Islands Region are derived from a variety of data sources (Table 2). During the early period, the foreign-reported database (held at AFSC) is the main source of information and was used to derive the official catch statistics until about 1980 when the observer data were introduced to provide more reliable estimates. The foreign and joint-venture (JV) blend data takes into account observer data and reported catches and forms the basis of the official catch statistics until 1990. The NMFS Observer data are the raw observed catch estimates and provide an indication of the amount of catch observed relative to the current estimates from the blend data. Since 1990 estimates of pollock discard were available, and these represented a small fraction of the total catch during the years when directed fishing was allowed (Table 3).

For the period 1977-1984, the foreign reported catch database was used to partition catches while for 1985-2003, observer data were used. These proportions were then expanded to match the total catch (Table 4; Fig. 1).

The distribution of observed catch differed between the JV years (1977-1989) and the domestic fishery (1989-2002; Fig. 2). In the early period, the JV fishery operated in the deep basin area extending westward to Bowers Ridge and in the eastern most portions of the Aleutian Islands. Some operations took place out to the west but observer coverage was limited. In the recent period (1989-1998, since the Aleutian Islands Region has been closed to directed pollock fishing since 1999) the fishery was more dispersed along the Aleutian Islands chain with no observed catches along Bowers Ridge and fewer operations in the deep basin area. Considering the spatial distribution of these fisheries, we recommended that the Aleutian Islands Region be broken into areas where apparent breaks existed (Fig. 3). These breaks separate the northern "basin" area from the Aleutian Islands chain and split the eastern-most portion of the Aleutian Islands Region from the Aleutian Islands. Two regional partitions were developed, one called NRA (for Near, Rat, and Andreanof Island groups) extending to 170°E, and another that excludes the eastern portion between 174°W and 170°W. The time series of catch estimates for these two groups is shown in Table 5. In the NRA area west of 174°W the fishery tended to concentrate in two distinct locations one on the north side of Atka Island around 174°W and the other near 177°W northwest of Adak Island. While the overall catch level was relatively low, the fishery moved far to the west in the 1998 (Fig. 4).

Fishery length frequency

The number of hauls and length samples in the NRA region west of 174°W are quite small compared with the eastern and northern (basin) areas (Table 6). However, the differences in the length frequencies appear to be substantial between regions (Fig. 5 and Fig. 6). During the early period, the region west of 174°W longitude was composed of smaller fish. This region also tended to have a broader range of lengths. The Basin region was similar to the eastern most region and the Bogoslof region (during the years when a fishery was allowed there). An investigation as to whether the change for the NRA region west of 174°W could be attributed to different seasonal concentrations of fishing showed that before 1990, the fishery tended to be more concentrated later in the year (Fig. 7), but inter-annually the fishery was consistent in the time between the eastern and western NRA (Fig. 8). Therefore differences in length distributions observed between these two regions cannot be attributed to differences in time of year the fishery was conducted. Intra-annual differences may show a trend that could be consistent with seasonality differences. The occurrence of larger fish later in the time series is likely due to the fishery targeting on spawning pollock. Pollock average weights-at-age from the early period are lower than the recent period (Fig. 9; Table 7). The observed proportion of females in the catch appeared to show a slight decline over this period (Fig. 10).

Fishery age composition

Catch-at-age composition estimates are made following Kimura (1989) and modified by Dorn (1992). Briefly, length-stratified age data are used to construct age-length keys for each stratum and sex. These keys are then applied to randomly sampled catch length frequency data. The stratum-specific age composition estimates are then weighted by the catch within each stratum to arrive at an overall age composition for each year. Data were collected through shore-side sampling and at-sea observers. The number of age samples and length samples was highly variable over this time period (Table 8). This problem is exacerbated for samples collected from different areas and gears (Table 9). The estimates for catch-age composition are shown in Table 10.

Survey data

Bottom trawl survey effort in the Aleutian Islands region has not been as extensive as in the eastern Bering Sea. The National Marine Fisheries Service in conjunction with the Fisheries Agency of Japan completed bottom trawl surveys for the Aleutian Islands region (from ~165°W to ~170°E) in 1980, 1983, and 1986. The Alaska Fisheries Science Center's Resource Assessment and Conservation Engineering Division (RACE) conducted bottom trawl surveys in this region in 1991, 1994, 1997, 2000, 2002 and 2004. Biomass estimates from the surveys conducted in the 1980s ranged between 309 and 779 thousand tons (mean 546). Biomass estimates from the five most recent RACE surveys ranged between 117 and 366 thousand tons (mean 225; Table 11). The biomass estimates from the early surveys are not comparable with the biomass estimates obtained from the RACE trawl surveys because of differences in the net, fishing power of the vessels, and sampling design. In the early surveys, biomass estimates were computed using relative fishing power coefficients (RFPC) and were based on the most efficient trawl during each survey. Such methods will result in pollock biomass estimates that are higher than those obtained using standard methods employed in the RACE surveys. Plotted on a simple catch-per-tow basis, the relative distribution of pollock appears to be highly variable between years and areas (Fig. 11).

All previous RACE Aleutian Islands bottom trawl (AIBT) surveys indicate that most of the pollock biomass has been located in the Eastern Aleutian Islands Area (Area 541) and along the north side of Unalaska-Umnak Islands in the eastern Bering Sea region (~165°W and 170°W). The 2004 Aleutian Islands trawl survey showed that the greatest densities and estimated biomass occur in the Unalaska-Umnak area in the eastern Bering Sea region. If we ignore the biomass estimates from the Unalaska-Umnak area the 2004 AIBT survey showed a very different pattern of biomass abundance than the 2002 survey (Fig. 11). Within the Aleutian Islands Region (Areas 541, 542, and 543) the 2002 AIBT survey indicated the highest densities and biomass were in the Central Aleutian Islands Area (Area 542) followed by the Eastern (Area 541) and Western areas (Area 543). In the 1991-2000 AIBT surveys the highest biomasses for the NRA Areas were estimated in Area 541 followed by Area 542 and Area 543. The earlier RACE AIBT surveys indicated a decline in pollock biomass in the portion of Area 541 east of 174°W longitude from a high of 53,865 mt in 1991 to a low of 28,985 mt in the 2000 survey. This trend was reversed in the 2002 survey with an estimate of 53,368 mt and in 2004 with an estimate of 111,250 mt (Table 11). In the 1991-2002 surveys a number of large to medium sized tows were encountered throughout the Aleutians indicative of a fairly well distributed population. This is very different from the 2004 survey estimate which indicated a low level of pollock abundance in both Area 542 and Area 543, and a much higher pollock density in Area 541. The 2004 survey revealed very few pollock throughout the NRA, except for a single large tow in Seguam pass. Roughly 100,000 mt of the 111,225 mt estimated for the area east of 174°W can be attributed to extrapolations from this single tow. Without this tow the biomass estimate in the entire NRA would be well below 40,000 mt. Since there has not been a fishery in the Aleutians, the survey has covered roughly the same grounds, and there has not been a change in survey methodology, the large decrease in pollock must be attributed to either a change in catchability due to vertical migration of pollock out of the reach of the bottom trawl, or a migration of pollock out of the surveyed area. Since the AIBT is limited to within the 500 m isobath the survey biomass estimates do not include mid-water pollock, nor do they include pollock located offshore from the 500m isobath. These biomass estimates therefore represent an unknown portion of the total biomass. The biomass in this area may be greater if the on-bottom/off-bottom distribution is similar to that of the eastern Bering Sea. In addition, climatic and year class variation may cause a difference in the proportion of pollock available to the bottom trawl survey.

Survey Length Frequencies

The 2004 AIBT survey found a large proportion of small fish (between 100 and 250 mm, indicative of 1 or 2 year old fish) in the NRA area west of 174°W, but very few small fish east of 174°W. The 2002 AIBT survey did not find very many small fish anywhere in the Aleutians. There were a large number of small fish observed in the 1994 and 2000 surveys throughout the NRA . The large numbers of 1 or 2 year old size pollock observed in the these surveys were assumed to have entered the fishable population in 1996 and 2002, respectively, and should have stabilized or increased pollock biomass in the Aleutian Islands in recent years. In the 2000, 2002, and 2004 AIBT survey differences in length distribution are apparent between areas east and west of 170°W longitude. Differences in pollock length distributions between the areas east and west of 174°W longitude in the NRA are not as apparent (Fig. 12).

In addition to the bottom trawl survey there has been one echo integration-trawl survey in a portion of the NRA. The R/V Kaiyo Maru conducted a survey between 170°W and 178°W longitude in the winter of 2002 after completing a survey of the Bogoslof region (Nishimura et al 2002; Fig. 13). Due to difficulties in operating their large mid-water trawl on the steep slope area they felt their catches in this area were insufficient for accurate species identification and biomass estimation. They did however come up with some preliminary biomass estimations. For the entire area from 170°W and 178°W longitudes they estimated a biomass of 93,000 mt of spawning pollock biomass with between 61,000 mt estimated in the NRA east of 173°W and 32,000 mt in the remainder of the survey area to 178°W longitude (Table 12). The largest aggregations in the NRA area were observed at 174°W longitude north of Atka Island. Most of the pollock echo sign was observed along the slope of the Aleutian Islands relatively near shore.

Analytic Approach

The 2005 Aleutian Islands walleye pollock stock assessment uses the same modeling approach as last year's model; through the Assessment Model for Alaska (here referred to as AMAK). AMAK is a variation of the "Stock Assessment Toolbox" model presented to the plan team in the 2002 Atka mackerel stock assessment, with some small adjustments to the model and a user-friendly graphic interface.

The abundance, mortality, recruitment, and selectivity of the Aleutian Islands pollock were assessed with a stock assessment model constructed with AMAK as implemented using the ADMB software. The ADMB is a C++ software language extension and automatic differentiation library. It allows for estimation of large numbers of parameters in non-linear models using automatic differentiation software developed into C++ libraries (Fournier 1998). The optimizer in ADMB is a quasi-Newton routine (Press et al. 1992). The model is determined to have converged when the maximum parameter gradient is less than a small constant (set to 1×10^{-7}). A feature of ADMB and AMAK is that it includes post-convergence routines to calculate standard errors (or likelihood profiles) for quantities of interest.

Model structure

The AMAK model models catch-at-age with the standard Baranov catch equation. The population dynamics follows numbers-at-age over the period of catch history with natural and age-specific fishing mortality occurring throughout the 14-age-groups that are modeled (ages 2-15+). Age-2 recruitment in each year is estimated as deviations from a mean value expected from an underlying stock-recruitment curve. Deviations between the observations and the expected values are quantified with a specified error model and cast in terms of a penalized log-likelihood. This overall log-likelihood (L) is the weighted sum of the calculated log-likelihoods for each data component and model penalties. The component weights are inversely proportional to the specified (or in some cases, estimated) variances. Appendix Tables 1 –3 provide a description of the variables used, and the basic equations describing the population dynamics of Aleutian Islands pollock and likelihood equations. The model was modified from that of Barbeaux et al. (2003). These modifications include a feature that allows a user-specified age-range for which to apply the survey (or other abundance index) catchability. For example, specifying the age-range of 6-10 (as was done for Aleutian Islands pollock) means that the average age-specific catchability of the survey is set to the parametric value (either specified as fixed, as in this assessment, or estimated). Also, in the 2003 assessment age-1 pollock were explicitly modeled whereas in the work presented here, they were dropped from consideration because observations of age-1 pollock are irregular, and in trials where they were included, they were found to limit the flexibility to incorporate alternative model specifications such as parametric forms of selectivity functions. The quasi[1] likelihood components and the distribution assumption of the error structure are given below:

Likelihood Component	Distribution Assumption
Catch biomass	Lognormal
Catch age composition	Multinomial
Survey catch biomass	Lognormal
Survey catch age composition	Multinomial
Recruitment deviations	Lognormal
Stock recruitment curve	Lognormal
Selectivity smoothness (in age-coefficients, survey and fishery)	Lognormal
Selectivity change over time (fishery only)	Lognormal
Priors (where applicable)	Lognormal

The age-composition components are heavily influenced by the sample size assumptions specified for the multinomial likelihood. Since sample variances of our catch-at-age estimates are available (Dorn 1992), "effective sample sizes" ($\dot{N}_{i,j}$) can be derived as follows (where *i* indexes year, and *j* indexes age):

$$\dot{N}_{i,j} = \frac{p_{i,j}\left(1-p_{i,j}\right)}{\mathrm{var}\left(p_{i,j}\right)}$$

where $p_{i,j}$ is the proportion of pollock in age group *j* in year *i* plus an added constant of 0.01 to provide some robustness. The variance of $p_{i,j}$ was obtained from the estimates of variance in catch-at-age. Thompson et al., (2003, p. 137) and Thompson (pers. comm.) show that the above is a random variable that has its own distribution. They show that the harmonic mean of this distribution is equal to the true sample size in the multinomial distribution. This property was used to obtain sample size estimates for the surveys and fishery numbers-at-age estimates:

Fishery data	Year	1978	1979	1980	1981	1982	1983	1984	1985	1987
	$\dot{N}_{i,\bullet}$	246	170	119	215	553	81	296	225	150
	Year	1990	1992	1993	1994	1995	1996	1997	1998	
	$\dot{N}_{i,\bullet}$	199	238	172	327	211	228	30	302	
Survey data										
	Year	1991	1994	1997	2000	2002	2004			
	$\dot{N}_{i,\bullet}$	1*	740	690	831	1124	774			

*The 1991 value was down-weighted by a factor of 1,000 because the samples collected in that year were not representative of the region considered.

Parameters

Parameters estimated independently

Natural Mortality

In the current assessment, a natural mortality value of 0.3 was used for all Models. We assume a fixed, constant value of *M* based on the studies of Wespestad and Terry (1984). Wespestad and Terry (1984) provide estimates

[1] The likelihood is *quasi* because model penalties (e.g., non-parametric smoothers) are included.

of M = 0.3 for ages 3+ (Table 13). Currently, the assessment model does not allow for age-specific natural mortality rates. It should be noted that in general, a higher natural mortality rate for age 2 pollock may be more appropriate (e.g., Ianelli et al. 2003) and that this model differs from the Eastern Bering Sea model in this manner. In the future, we will be investigating methods to improve AMAK to include age varying natural mortality.

Length and Weight at Age

We estimated length and weight at age separately for the survey and for the fishery. We obtained survey estimates from AIBT surveys and computed fishery estimates from observer data. For the time period between 1978 and 1990 the von Bertalanffy growth curve parameters and length weight regression parameters for length and weight at age estimates for surveys were estimated for the 1980, 1983, and 1986 AIBT surveys (Table 14). For the time period between 1990 and 2003 we calculated the average length at age by weighted averages by age and calculated the length-weight relationships using linear regression analysis. Data for these analyses were retrieved from the Resource Assessment and Conservation Engineering Division's (RACE) survey database. Length and weight at age data were available for the 1991, 1994, 1997, 2000, and 2002 AIBT surveys. For years without survey length and weight at age data we used the mean values at age for the two nearest surveys (Table 15). Fishery data east of 174°W longitude were excluded from the data set for calculating length and weight at age. For the fishery, we used year (when available) and age-specific estimates of average weights-at-age as computed from the fishery age and length sampling programs from data collected west of 174°W. These values (Table 16) are important for converting model estimated catch-at-age (in numbers) to estimated total annual harvests (by weight).

Maturity at Age

Maturity at age schedule is based on the studies of Wespestad and Terry (1984; Table 17). An updated analysis on maturity-at-age using more recent data has been completed and is presented in the 2005 Bering Sea pollock stock assessment. In summary the data collected in 2002 and 2003 are in agreement with that observed by Westpestad and Terry (1984) and a change in model configuration is not warranted at this time.

Parameters estimated conditionally

Deviations between the observations and the expected values are quantified with a specified error structure. Lognormal error is assumed for estimates of survey and fishery catch, and a multinomial error structure is assumed for analysis of the survey and fishery age compositions. These error structures are used to estimate the following parameters conditionally within the model.

Fishing Mortality

Fishing mortality in all models was parameterized to be separable with both an age component (selectivity) and a year component. In all models selectivity is conditioned so that the mean value over all ages will be equal to one. To provide regularity in the age component, a penalty was imposed on sharp shifts in selectivity between ages using the sum of squared second differences. In addition, the age component parameters are assumed constant for the last 4 age groups (ages 12-15). Finally selectivity was allowed to vary over time. The model was set with controls selecting the degree to which selectivity is allowed to change between ages and over time.

Survey Catchability

For the bottom trawl survey, survey catchability-at-age follows the parameterization similar to the fishery selectivity-at-age presented above. The catchability-at-age relationship is modeled with a smoothed non-parametric relationship that can take on any shape (with penalties controlling the degree of change and curvature specified by the user). To provide regularity in the age component, a penalty was imposed on sharp shifts in catchability-at-age between ages using the sum of squared second differences. In addition, the age component parameters are assumed constant for the last 4 age groups (ages 12-15). As noted above, the model allows specification of the age-range over which the catchability parameter is applied. For Aleutian Islands pollock, ages 6-10 were selected to have the average catchability (factoring selectivity components) equal to the catchability parameter value.

In the 2004 Aleutian Islands pollock stock assessment, the focus of our analysis was to evaluate a key model assumption: the extent to which the NMFS summer bottom trawl survey catchability should be estimated by the available data (resulting in very high stock sizes) or constrained to be close to a value of 1.0 (implying that the area-swept survey method during the summer months reasonably applies to a fishery that will likely occur during the winter). We provided evidence that suggests that fixing the value of survey catchability to 1.0 is unreasonable. However, recognizing that no other information is available to "anchor" the assessment model to an absolute biomass level, the authors were reluctant to proceed with specifying influential prior distributions on catchability values. The effects of the fishery on the pollock population dynamics appear to be poorly determined given the available data. This could be due to a number of factors including: characteristics of Aleutian Islands pollock relative to adjacent regions, poor quality data, and the possibility that the fishing effects are minor relative to other factors. The latter point is likely to be true at least for the recent period where the fishery removals have been minor since 1999. We have therefore selected a fixed catchability value of 1.00 for our 2005 preferred alternative models.

Recruitment

A reparameterized form of the Beverton-Holt stock recruitment relationship based on Francis (1992) was used. Values for the stock recruitment function parameters α and β are calculated from the values of R_0 (the number of 0-year-olds in the absence of exploitation and recruitment variability) and the "steepness" (h) of the stock-recruit relationship. The "steepness" parameter is the fraction of R_0 to be expected (in the absence of recruitment variability) when the mature biomass is reduced to 20% of its pristine level (Francis 1992). As an example, a value of h = 0.8 implies that at 20% of the unfished spawning stock size will result in an expected value of 80% of the unfished recruitment level. The steepness parameter (h) was estimated with a prior of 0.7 and CV of 0.2, and sigma r was set at 0.6 for all model runs.

Model evaluation

For this report, two models are presented (Model 1 and Model 2). Parameter configurations for both models are the same with a survey catchability of 1.0 and steepness centered on 0.7 with a CV of 0.2 as a (normal) prior distribution and sigma r of 0.6. The data configuration for the two models differ in that Model 1 contains only survey data from the NRA area west of 174º W longitude and Model 2 contains survey data from the entire NRA region.

Model 2 was developed for two reasons: a) in response to 2004 SSC comments on the 174°W data division line, and b) the apparent shift of pollock biomass to the east in the 2004 survey. Model 2, like Model 1, is configured with only the fishery data from the NRA area west of 174º W. We strongly believe that the 174°W data division line for the fishery data is essential for the proper characterization of Aleutian Islands pollock stock dynamics.

Relative differences in model fits are shown in Table 18 and key results are presented in Table 19. By including the survey biomass from the area east of 174°W Model 2 did show a marked improvement in fit from Model 1 based on lowest quasi-likelihood. This is primarily due to a better fit to the survey index, but Model 2 does provide a better fit to all of the data components. A better fit to the survey index by model 2 can be attributed to the lower intra-annual variability in the NRA-wide biomass estimate with a much smoother trend which allows for a better fit to the model.

For Model 1 the fit to the survey data is relatively poor, but not surprisingly so given the estimates of variance for the individual survey point estimates (Fig. 14) and the high intra-annual variability of the estimates. For both models the fit to the survey age composition data was excellent, except for the 1991 data which, for sampling reasons, was given less weight than for the other years (Fig. 15). Results of fits to the fishery age-composition data were much poorer, the high variability in the age data probably reflects the diversity in sampling locations for the fishery in different years (Fig. 16). The time-varying selectivity patterns estimated by the models show only slight changes for the survey, but a relatively large shift (to older fish) after 1990 for the fishery data (Fig. 17) coinciding with the change from a foreign fishery to a domestic fishery targeting spawning aggregations.

Because of the uncertainty in the stock structure of pollock in the Aleutian Islands region, both model configurations are presented in the results section. The authors feel that the results from both models provide insight into the health of the stock and believe it appropriate to present both sets of model results in parallel.

Results

Abundance and exploitation trends

Key results of fitting the two models are their differences in age 2+ biomass trajectories and numbers at age (Fig. 18, Table 20 and Table 21). Fishing mortality and exploitation rates were higher in Model 1 than in Model 2, but the trends in exploitation were the same. Both models show high peaks in exploitation in the late 1990's. The models differ in that Model 1 has the highest fishing mortality in 1998 with F=0.49 and Catch/biomass at 21%, while for Model 2 fishing mortality and exploitation rates peak in 1995 with F=0.34 and Catch/biomass at 15% (Table 22). Model 2 shows continued higher than average exploitation in 1997 and 1998 with F=0.288 and 0.272 respectively.

As seen in last year's analysis (Barbeaux et al, 2004), the abundance trend is highly conditioned on the assumptions made about the area-swept survey trawl assumptions on catchability. Even with catchability fixed at 1.0, the uncertainty in the trend and level is very high (Fig. 19). Bearing in mind the high degree of uncertainty, the stock trend appears to be stable to increasing after 2000.

Recruitment

For both models estimates of recruitment (at age 2) are estimated with high variance (Fig. 20). The 1978 year-class is the largest for both models (681 and 847 million age 2 recruits for Model 1 and Model 2, respectively). The 1989 year class is the second largest in Model 1 (226 million age 2 recruits), while in Model 2, the 2000 and 1989 year classes are very close (289 and 288 million age 2 recruits for 2000 and 1989, respectively). In Model 1 the 2000 year class is large (110 million age 2 recruits), but less than half of that predicted for 1989 (Table 23). Whether AI pollock recruitment is synchronous with other areas is an open question (e.g., the 1978,1989, and 2000 year classes are also strong in the EBS region, Ianelli et al. 2003). An alternative explanation is that movement from other areas may affect year-class abundance. The extent to which adjacent stocks interact is an active area of research.

Markof Chain Monte Carlo Results

Markof Chain Monte Carlo (MCMC) runs were completed for Model 1, and Model 2. One million MCMC simulations sampled at every 200th iteration were conducted for each of the models. Model 1 resulted in an estimated biomass with a relatively tight distribution about the mean. Model 2 resulted in an estimate of biomass with a broader distribution about the mean (Fig. 21). Both Model 1 and Model 2 were able to provide estimates of steepness with a mean of 0.55 and CV of 0.35 for Model 1 and a mean of 0.66 and CV of 0.26 for Model 2 (Table 24) . The MCMC trace for the 2005 total biomass in both Model 1 and Model 2 shows a stable trajectory with the 200th iteration sampling schema (Fig. 22).

Summary of results

We assessed two models (Model 1 and Model 2) with fixed catchability at 1.00. These models differ in the survey data input. Model 1 excludes survey data from east of 174°W longitude, while Model 2 includes these data. Although Model 2 appears to provide a better fit (lower negative log-likelihood for every data component and lower total quasi-likelihood), overall fit to the data may not be the best method of comparison since the two models do not differ in model configuration but rather in data configuration. Model 2 fits the survey biomass index data better than Model 1, but the data used in Model 2 is highly uncertain (high CV) which appear to have smoother transitions between surveys. As with the fishery data, the survey data from east of 174°W may be significantly influenced by abundance trends in the eastern Bering sea and thus may not be a good index for the western NRA pollock population.

Projections and harvest alternatives

For projection purposes we use the yield projections estimated for Model 1 and Model 2. Because a directed fishery on pollock has been banned since 1999 we do not believe the 2005 AI pollock selectivity-at-age assumed in these models would be relevant to a newly opened directed fishery. For projections we used the selectivity-at-age derived from the 2005 EBS pollock assessment (Ianelli, et al 2004), because a current estimate for selectivity-at-age for a directed pollock fishery in the Aleutians is not available (Table 25). The selectivity-at-age for the EBS pollock would be applicable if an Aleutian Islands Pollock fishery was prosecuted by EBS pollock fishing vessels. Both models have catchability fixed at 1.0, Model 1 excludes all data from east of 174°W, while Model 2 only excludes fishery data from east of 174°W.

Reference fishing mortality rates and yields

Amendment 56 to the BSAI Groundfish Fishery Management Plan (FMP) defines "overfishing level" (OFL), the fishing mortality rate used to set OFL (F_{OFL}), the maximum permissible ABC, and the fishing mortality rate used to set the maximum permissible ABC (*max* F_{ABC}). The fishing mortality rate used to set ABC (F_{ABC}) may be less than or equal to this maximum permissible level. The overfishing and maximum allowable ABC fishing mortality rates are given in terms of percentages of unfished female spawning biomass ($F_{SPR\%}$), on fully selected age groups. The associated long-term average female spawner biomasses that would be expected under average estimated recruitment from 1978-2003 (Model 1 = 96.7 million age 2 recruits, or Model 2 = 159.7 million age 2 recruits) and F equal to $F_{40\%}$ and $F_{35\%}$ are denoted $B_{40\%}$ and $B_{35\%}$, respectively. The Tiers require reference point estimates for biomass level determinations. We present the following reference points for NRA pollock for Tier 3 of Amendment 56. For our analyses, we selected the following values from Models 1 and 2:

Female spawning biomass	Model 1	Model 2
$B_{100\%}$	127,783 mt	186,874 mt
$B_{40\%}$	51,113 mt	74,750 mt
$B_{35\%}$	44,724 mt	65,410 mt

Specification of OFL and Maximum Permissible ABC

For Models 1 and 2, the projected year 2006 female spawning biomass (SB_{06}) is estimated to be 66,177 mt and 174,430 mt under the maximum allowable ABC harvest strategy ($F_{40\%}$). The projected 2006 female spawning biomass respectively, is above the $B_{40\%}$ value of 51,113 mt for Model 1 placing NRA pollock in Tier 3a, and above the $B_{40\%}$ value of 74,750 mt for Model 2 also placing NRA pollock in Tier 3a. The maximum permissible ABC and OFL values under Tier 3a are:

Model 1 Tier 3a:

Harvest Strategy	FSPR%	Fishing Mortality Rate	2006 Projected yield (mt)
max F_{ABC}	$F_{40\%}$	0.32	35,290 mt
F_{OFL}	$F_{35\%}$	0.41	42,910 mt

Model 2 Tier 3a:

Harvest Strategy	FSPR%	Fishing Mortality Rate	2006 Projected yield (mt)
$max\ F_{ABC}$	$F_{40\%}$	0.37	102,590 mt
F_{OFL}	$F_{35\%}$	0.48	124,780 mt

ABC Considerations and Recommendation

ABC Considerations

There remains considerable uncertainty in the Aleutian Islands pollock assessment. We've noted some concerns below:

1) The amount of interaction between the Aleutian stock and the Eastern Bering Sea stock is unknown. It is evident that some interaction does occur and that the abundance and composition of the eastern portion of the Aleutian Islands stock is highly confounded with that of the Eastern Bering Sea stock. Overestimation of the Aleutian Islands pollock stock productivity due to an influx of Eastern Bering Sea stock is a significant risk.

2) As assessed in the 2004 AI pollock stock assessment (Barbeaux et al. 2004), AIBT survey catchability is probably less than 1.0, but we have no data to concretely anchor the value at anywhere less than 1.0. We therefore employed a default value for catchability of 1.00 (a conservative estimate). This provides a conservative total biomass estimate.

3) AIBT survey estimates of biomass are very uncertain with an average CV of 0.34. The 2002 and 2004 estimates are especially uncertain with CVs of 0.38 and 0.78 respectively. This results in considerable uncertainty in the projections.

4) The assessed models only have survey and fishery age composition data available for the 1990s. Therefore, because of the selectivity-at-age assumed in these models we may be underestimating the 1978 year class. Results from Model 1 and Model 2 are therefore conservative estimates.

5) All of the differences between Model 1 and Model 2 are due to the inclusion of survey biomass and survey age data from the NRA area east of 174°W.

ABC Recommendations

The pollock biomass in the NRA appears to be increasing in both models, even in light of the latest low values for the AIBT survey. The total age 3+ biomass for 2006 is expected to be (Model 1) 180,121 mt or (Model 2) 362,057 mt. The estimated female spawning biomass projected for 2006 is expected to be (Model 1) 66,177 mt or (Model 2) 174,430 mt. The year 2006 maximum permissible ABC for Model 1, based on $F_{40\%}$, is 35,290 mt (F=0.32) and for Model 2 is 102,590 mt (F=0.37). Given the better overall fit of Model 2 to the available data we feel it provides the better overall representation of the pollock stock dynamics for the entire NRA region. Although Model 2 provides a tighter fit to the available data, we strongly believe that the 2006 Model 2 catch is not adequately precautionary given the high degree of uncertainty in the 2002 and 2004 AIBT estimate and the lack of fisheries data since 1998. The authors therefore recommend the use of the long-term expected yield (equilibrium F_{ABC}) from Model 2 for an ABC of 41,650 mt.

Under Tier 5 with a natural mortality of 0.3 the 2006 ABC would be 29,351 mt (130,450 mt x 0.75 x 0.30 = 29,351mt).

Standard Harvest Scenarios and Projection Methodology

A standard set of projections is required for each stock managed under Tiers 1, 2, or 3, of Amendment 56. This set of projections encompasses seven harvest scenarios designed to satisfy the requirements of Amendment 56, the National Environmental Policy Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA).

For each scenario, the projections begin with the vector of 2005 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2006 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 2005. In each subsequent year, the fishing mortality rate is prescribed on the basis of the spawning biomass in that year and the respective harvest scenario. In each year, recruitment is drawn from an inverse Gaussian distribution whose parameters consist of maximum likelihood estimates determined from recruitments estimated in the assessment. Spawning biomass is computed in each year based on the time of peak spawning and the maturity and weight schedules described in the assessment. Total catch is assumed to equal the catch associated with the respective harvest scenario in all years. This projection scheme is run 1000 times to obtain distributions of possible future stock sizes, fishing mortality rates, and catches.

Five of the seven standard scenarios will be used in an Environmental Assessment prepared in conjunction with the final SAFE. These five scenarios, which are designed to provide a range of harvest alternatives that are likely to bracket the final TAC for 2005, are as follows (a "*max* F_{ABC}" refers to the maximum permissible value of F_{ABC} under Amendment 56):

Scenario 1: In all future years, F is set equal to *max* F_{ABC}. (Rationale: Historically, TAC has been constrained by ABC, so this scenario provides a likely upper limit on future TACs.)

Scenario 2: In all future years, F is set equal to a constant fraction of *max* F_{ABC}, where this fraction is equal to the ratio of the F_{ABC} value for 2006 recommended in the assessment to the *max* F_{ABC} for 2006. (Rationale: When F_{ABC} is set at a value below *max* F_{ABC}, it is often set at the value recommended in the stock assessment.)

Scenario 3: In all future years, F is set equal to 50% of max F_{ABC}. (Rationale: This scenario provides a likely lower bound on F_{ABC} that still allows future harvest rates to be adjusted downward when stocks fall below reference levels.)

Scenario 4: In all future years, F is set equal to the 2001-2005 average F. (Rationale: For some stocks, TAC can be well below ABC, and recent average F may provide a better indicator of F_{TAC} than F_{ABC}.)

Scenario 5: In all future years, F is set equal to zero. (Rationale: In extreme cases, TAC may be set at a level close to zero.)

Two other scenarios are needed to satisfy the MSFCMA's requirement to determine whether a stock is currently in an overfished condition or is approaching an overfished condition. These two scenarios are as follow (for Tier 3 stocks, the MSY level is defined as $B_{35\%}$):

Scenario 6: In all future years, F is set equal to FOFL. (Rationale: This scenario determines whether a stock is overfished. If the stock is expected to be 1) above its MSY level in 2006 or 2) above ½ of its MSY level in 2006 and above its MSY level in 2006 under this scenario, then the stock is not overfished.)

Scenario 7: In 2006 and 2007, F is set equal to *max* F_{ABC}, and in all subsequent years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is approaching an overfished condition. If the stock is expected to be above its MSY level in 2018 under this scenario, then the stock is not approaching an overfished condition.)

The author included one more scenario in order to take into consideration a TAC set at 19,000 t for all future years.

Scenario 8: In 2006 through 2018 the TAC is set at 19,000 t. (Rationale: This scenario seems like a plausible outcome given the current management strategy in the Aleutians.)

Projections and status determination

Model 1

The projected age 3+ biomass at the beginning of 2006 for Model 1 is 180,121 mt and the projected 2006 female spawning biomass is 66,177 mt ($B_{52\%}$). The projected yields, female spawning biomass, and the associated fishing mortality rates for the seven harvest strategies for Model 1 are shown in Table 26. For Model 1 under a harvest strategy of $F_{40\%}$ (Scenario 1), female spawning biomass is projected to be above $B_{40\%}$ for the entire 13 year projection (Fig 23 and Fig 24).

Female spawning biomass is projected to fall below $B_{40\%}$ when fishing at F_{OFL} (Scenarios 6 & 7, Table 26) for the later years of the projection, but remain above $B_{35\%}$ for all scenarios and projection years. It should be noted that in the projections, the fishing mortality rates are prescribed on the basis of the harvest scenario and the spawning biomass in each year. Thus, fishing mortality rates may not be constant within the projection if spawning biomass drops below $B_{40\%}$ in any run.

The associated long-term average female spawner biomass that would be expected under average estimated recruitment from 1978-2003 (96.7 million recruits) and $F = F_{35\%}$, denoted $B_{35\%}$ is estimated to be 44,724 mt. This value ($B_{35\%}$), is used in the status determination criteria. Female spawning biomass for 2006 (66,177 mt) is projected to be above $B_{35\%}$ thus, the NRA pollock stock would be determined to be *above* its minimum stock size threshold (MSST) and is *not overfished*. Female spawning biomass for 2008 is projected to be above $B_{35\%}$ in scenario 7, thus the NRA pollock stock is *not* expected to fall below its MSST in two years and is *not approaching an overfished condition*.

Scenario 8 (Fig. 22, Fig. 23, and Table 26) shows that a constant harvest of 19,000 mt would be a conservative harvest strategy under Model 1, resulting in $F_{06} = 0.16$ and a relatively flat, but increasing, female spawning stock biomass trajectory.

Model 2

The projected age 3+ biomass at the beginning of 2006 for Model 2 is 362,057 mt, and the projected 2006 female spawning biomass is 174,430 mt ($B_{93\%}$). The projected yields, female spawning biomass, and the associated fishing mortality rates for the seven harvest strategies for Model 2 are shown in Table 27. For Model 2 under a harvest strategy of $F_{40\%}$ (Scenario 1), female spawning biomass is projected to be above $B_{40\%}$ for all 13 years of the projection. Female spawning biomass is projected to fall below $B_{40\%}$ when fishing at F_{OFL} (Scenarios 6 & 7, Table 27) in 2009 and remain below for the remainder of the projection. Please note again that the fishing mortality rates are prescribed on the basis of the harvest scenario and the spawning biomass in each year. Thus, fishing mortality rates may not be constant within the projection if spawning biomass drops below $B_{40\%}$ in any run.

The associated long-term average female spawner biomass that would be expected under average estimated recruitment from 1978-2003 (159.7 million recruits) and $F = F_{35\%}$, denoted $B_{35\%}$ is estimated to be 65,410 mt. This value ($B_{35\%}$), is used in the status determination criteria. Female spawning biomass for 2006 (174,430 mt) is projected to be above $B_{35\%}$ thus, the NRA pollock stock would be determined to be *above* its minimum stock size threshold (MSST) and is *not overfished*. Female spawning biomass for 2008 is projected to be above $B_{35\%}$ in scenario 7, thus the NRA pollock stock is *not* expected to fall below its MSST in two years and is *not approaching an overfished condition*.

Scenario 8 (Fig. 22, Fig. 23, and Table 27) shows that a constant harvest of 19,000 mt would be a conservative harvest strategy under Model 2, resulting in $F_{06} = 0.06$ and a slowly declining female spawning stock biomass trajectory as would be expected for a stock at $B_{93\%}$.

Ecosystem Considerations

Ecosystem considerations for Aleutian Islands walleye pollock are summarized in Table 28.

Ecosystem effects on Aleutian Islands Walleye Pollock

Prey availability/abundance trends

Adult walleye pollock in the Aleutian Islands consume a variety of prey, primarily large zooplankton, copepods, and myctophids. Figure 25 highlights the trophic level of pollock in relation to its prey and preditors. No time series of information is available on Aleutian Islands for large zooplankton, copepod, or myctophid abundance.

Predator population trends

Walleye pollock are consumed by a variety of piscivores, including, marine mammals, and seabirds (Fig. 26). The abundance trend of Aleutian Islands Pacific cod is decreasing, and the trend for Aleutian Islands arrowtooth flounder is relatively stable. Northern fur seals are showing declines, and Steller sea lions have shown some slight increases. Declining trends in predator abundance could lead to possible decreases in walleye pollock mortality. The population trends of seabirds are mixed, some increases, some decreases, and others stable. Seabird population trends could affect young-of-the-year mortality.

Changes in habitat quality

The 2004 Aleutian Islands summer bottom temperatures indicated that 2004 was an average year. This is a warming trend since the 2002 survey was the second coldest year after the 2000 survey. Bottom temperatures could possibly affect fish distribution, but there have been no directed studies, and there is no time series of data which demonstrates the effects on Aleutian Islands walleye pollock.

AI pollock fishery effects on the ecosystem

AI pollock fishery contribution to bycatch

The AI pollock fishery opening in 2005 was limited to only four hauls, within these four hauls the bycatch level of pacific ocean Perch was very high (~50%). Besides the lack of commercially harvestable levels of pollock, the high levels of POP bycatch convinced fishers to discontinue the fishery in 2005. Prior to 1998 levels of bycatch in the pollock fishery of prohibited species, forage, HAPC biota, marine mammals and birds, and other sensitive non-target species was very low compared to other fisheries in the region.

Concentration of AI pollock catches in time and space

Since the AI pollock fishery is expected to be a winter roe fishery and the distribution of pollock in the winter around the Aleutian Islands is expected to follow that observed in 2002 during the R/V Kiayo Maru EIT winter survey, there is expected to be a concentration of effort in small areas between Steller sea lion critical habitat closures. The impacts of this fishery due to temporal and spatial concentration are not expected be substantial due to the relatively low fishing mortality expected. In addition, less than 25% of the Aleutian Islands shelf area is open to directed fishing for pollock, limiting impacts to a relatively few small areas which have been designated as less important to potentially impacted species, such as the Steller sea lion.

AI pollock fishery effects on amount of large size walleye pollock

The AI pollock fishery in the Aleutian Islands was closed between 1999 and 2005. There was only a very limited fishery (< 200mt) in 2005. Year to year differences observed in the previous seven years can not be attributed to the fishery and must be attributed to natural fluctuations in recruitment. Fishers have indicated that the larger pollock in the Aleutian Islands will be targeted. But the low level of fishing mortality is not expected to greatly affect the size distribution of pollock in the AI.

AI pollock fishery contribution to discards and offal production

The 2006 Aleutian Islands pollock fishery, if pursued, is expected to be conducted by catcher processor vessels. Many of the pollock catcher processor vessels have fish meal processing plants, and therefore very little discard or offal production is expected from this fishery.

AI Pollock fishery effects on AI pollock age-at-maturity and fecundity

The effects of the fishery on the age-at-maturity and fecundity of AI pollock are unknown. No studies on AI pollock age-at-maturity or fecundity have been conducted. Studies are needed to determine if there have been changes over time and whether changes could be attributed to the fishery.

Data gaps and research priorities

Very little is known about the AI pollock stock structure and their relation to Western Bering Sea, Eastern Bering Sea, Gulf of Alaska, Bogoslof and Central Bering Sea pollock. Genetic work on the relationship of NRA pollock to other stocks in the North Pacific is essential for further assessment work. In addition, studies on the migration of pollock in the North Pacific should be explored in order to obtain an understanding of how the stocks relate spatially and temporally and how neighboring fisheries affect local abundances. Time series data sets on prey species abundance in the Aleutian Islands would be useful for a more clear understanding of ecosystem affects. Studies to determine the impacts of environmental indicators such as temperature regime on AI Aleutian pollock are needed. Currently, we rely on studies from the eastern Bering Sea for our estimates of life history parameters (e.g. maturity-at-age, fecundity, and natural mortality) for the NRA pollock. Studies specific to the NRA to determine whether there are any differences from the eastern Bering Sea stock and whether there have been any changes in life history parameters over time would be informative.

Summary

Model Parameters			
Natural Morality:		$M = 0.3$	
Initial Biomass (1978):	Model 1	$B_0 = 451{,}420$ mt	
	Model 2	$B_0 = 593{,}750$ mt	
2006 (Tier 3a)			
Maximum permissible ABC:	Model 1	$F_{40\%} = 0.32$	yield = 35,290 mt
	Model 2	$F_{40\%} = 0.37$	yield = 102,590 mt
	Tier 5 (M = 0.3)		yield = 29,350 mt
Overfishing (OFL):	Model 1	$F_{35\%} = 0.41$	yield = 42,910 mt
	Model 2	$F_{35\%} = 0.48$	yield = 124,780 mt
	Tier 5 (M=0.3)		yield = 39,100 mt
2007 (Tier 3a)			
Maximum permissible ABC:	Model 1	$F_{40\%} = 0.32$	yield = 30,840 mt
	Model 2	$F_{40\%} = 0.37$	yield = 72,610 mt
	Tier 5 (M = 0.3)		yield = 29,350 mt
Overfishing (OFL):	Model 1	$F_{35\%} = 0.41$	yield = 35,080 mt
	Model 2	$F_{35\%} = 0.48$	yield = 79,850 mt
	Tier 5 (M=0.3)		yield = 39,100 mt

2006 and 2007 Long-term Expected Yield (**Recommended**)

Maximum permissible ABC:	**Model 2 LTEY* F_{abc} = 0.17**	**yield =**	**41,650 mt**
Overfishing (OFL):	**Model 2 LTEY* F_{ofl} = 0.17**	**yield =**	**44,860 mt**

Equilibrium female spawning biomass

Model 1			Model 2		
$B_{100\%}$	=	127,783 mt	$B_{100\%}$	=	186,874 mt
$B_{40\%}$	=	51,113 mt	$B_{40\%}$	=	74,750 mt
$B_{35\%}$	=	44,724 mt	$B_{35\%}$	=	65,410 mt

Projected 2006 biomass

Model 1			Model 2		
Age 3+ biomass	=	180,121 mt	Age 3+ biomass	=	362,057 mt
Female spawning biomass	=	66,177mt	Female spawning biomass	=	174,430 mt

* LTEY is the Long-term expected yield under Model 2 at $F_{40\%}$ for ABC and $F_{35\%}$ for OFL recommended by the 2004 BSAI plan team.

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Tables

Table 1. Time series of ABC, TAC, and total catch for Aleutian Islands Region walleye pollock fisheries 1991-2005. Units are in metric tons. Note: There was no OFL level set in 1991 and the 1993 harvest specifications were not available

YEAR	ABC	TAC	OFL	CATCH	CATCH/TAC
1991	101,460	72,250	NA	98,604	136%
1992	51,600	47,730	62,400	52,352	110%
1993				57,132	
1994	56,600	56,600	60,400	58,659	104%
1995	56,600	56,600	60,400	64,925	115%
1996	35,600	35,600	47,000	29,062	82%
1997	28,000	28,000	38,000	25,940	93%
1998	23,800	23,800	31,700	23,822	100%
1999	23,800	2,000	31,700	1,010	51%
2000	23,800	2,000	31,700	1,244	62%
2001	23,800	2,000	31,700	824	41%
2002	23,800	1,000	31,700	1,156	116%
2003	39,400	1,000	52,600	1,653	165%
2004	39,400	1,000	52,600	1,150	115%
2005	29,400	19,000	39,100	1,556	8%

Table 2. Estimates of walleye pollock catches from the entire Aleutian Islands Region by source, 1977-2003. Units are in metric tons.

Year	Official Foreign & JV Blend	Domestic Blend	Foreign Reported	NMFS Observer Data	Current estimates
1977	7,367		7,827	5	7,367
1978	6,283		6,283	234	6,283
1979	9,446		9,505	58	9,446
1980	58,157		58,477	883	58,157
1981	55,517		57,056	2,679	55,517
1982	57,753		62,624	11,847	57,753
1983	59,021		44,544	12,429	59,021
1984	77,595		67,103	48,538	77,595
1985	58,147		48,733	43,844	58,147
1986	45,439		14,392	29,464	45,439
1987	28,471			17,944	28,471
1988	41,203			21,987	41,203
1989	10,569			5,316	10,569
1990		79,025		51,137	79,025
1991		98,604		20,493	98,604
1992		52,352		20,853	52,352
1993		57,132		22,804	57,132
1994		58,659		37,707	58,659
1995		64,925		18,023	64,925
1996		29,062		5,982	29,062
1997		25,940		5,580	25,940
1998		23,822		1,882	23,822
1999		1,010		24	1,010
2000		1,244		75	1,244
2001		824		88	824
2002		1,156		144	1,156
2003		1,653			1,653
2004		1,150			1,150
2005		1,610			1,610

Table 3. Estimated walleye pollock catch discarded and retained for the Aleutian Islands Region based on NMFS blend data, 1991-2001.

Year	Catch Retained	Discard	Total	Discard Percentage
1990	69,682	9,343	79,025	12%
1991	93,059	5,441	98,500	6%
1992	49,375	2,986	52,361	6%
1993	55,399	1,740	57,138	3%
1994	57,308	1,373	58,681	2%
1995	63,545	1,380	64,925	2%
1996	28,067	994	29,062	3%
1997	25,323	617	25,940	2%
1998	23,657	164	23,822	1%
1999	361	446	807	55%
2000	455	790	1,244	64%
2001	445	380	824	46%
2002	398	758	1,156	66%
2003	1184	468	1,653	28%
2004	871	278	1,150	24%

Table 4. Estimates of Aleutian Islands Region walleye pollock catch by the three management sub-areas. Foreign reported data were used from 1977-1984, from 1985-2003 observer data were used to partition catches among the areas. Units are in metric tons.

Year	East (541)	Central (542)	West (543)	Total
1977	4,402	0	2,965	7,367
1978	5,267	712	305	6,283
1979	1,488	1,756	6,203	9,446
1980	28,284	7,097	22,775	58,157
1981	43,461	10,074	1,982	55,517
1982	54,173	1,205	2,376	57,753
1983	56,577	1,250	1,194	59,021
1984	64,172	5,760	7,663	77,595
1985	19,885	38,163	100	58,147
1986	38,361	7,078	0	45,439
1987	28,086	386	0	28,471
1988	40,685	517	0	41,203
1989	10,569	0	0	10,569
1990	69,170	9,425	430	79,025
1991	98,032	561	11	98,604
1992	52,140	206	6	52,352
1993	54,512	2,536	83	57,132
1994	58,091	554	15	58,659
1995	28,109	36,714	102	64,925
1996	9,226	19,574	261	29,062
1997	8,110	16,799	1,031	25,940
1998	1,837	3,858	18,127	23,822
1999	484	420	105	1,010
2000	615	461	169	1,244
2001	332	386	105	824
2002	842	180	133	1,156
2003	569	758	326	1,653

Table 5. Estimates of pollock catch (metric tons) by new area definitions. "NRA" stands for Near, Rat, and Andreanof island groups, "NRA w/o E" signifies the NRA region without the area east of 174°W, "Basin" represents the northern portions of areas 541 and 542. See Fig. 3 for locations on a map. (*Note: 1977-1984 area assignments are based on foreign reported data, 1985- 2003 are based on observer data).*

Year	NRA	NRA w/o E	Basin	Basin + E
1977	7,367	2,965	0	4,402
1978	6,283	1,016	0	5,267
1979	9,446	7,959	0	1,488
1980	58,157	29,873	0	28,284
1981	31,258	14,811	24,259	40,706
1982	50,322	3,149	7,863	54,605
1983	44,442	1,669	15,354	57,352
1984	42,901	9,171	39,140	68,424
1985	47,070	870	48,472	57,278
1986	23,810	704	28,003	44,735
1987	26,257	2,720	2,251	25,752
1988	36,864	574	4,339	40,628
1989	10,569	0	0	10,569
1990	79,025	10,477	0	68,548
1991	98,604	561	230	98,043
1992	52,352	8,519	29,455	43,833
1993	57,132	16,162	22,404	40,970
1994	58,659	5,965	26,288	52,694
1995	64,925	58,203	3,015	6,723
1996	29,062	23,187	899	5,875
1997	25,940	25,774	0	166
1998	23,822	23,335	67	486
1999	1,010	631	0	378
2000	1,244	891	0	354
2001	824	575	0	249
2002	1,156	351	1	805
2003	1,653	1,430	0	222
2004	1,150	962	0	188
2005	1,610	1,330	0	280

Table 6. Sampling levels in Aleutian Islands Region sub-regions based on foreign, J.V., and domestic walleye pollock observer data 1978 – 1998.

	NRA West of 174° Longitude			**NRA East of 174° Longitude**			**Aleutian Islands Area Basin**		
Year	Fish Measured	Hauls Sampled	Vessels Sampled	Fish Measured	Hauls Sampled	Vessels Sampled	Fish Measured	Hauls Sampled	Vessels Sampled
1978	1,503	64	4	4,831	135	11	0	0	0
1979	1,317	16	4	977	33	6	0	0	0
1980	2,154	53	4	4,753	119	10	0	0	0
1981	4,782	37	7	6,617	96	14	1,913	15	3
1982	7,713	102	13	29,549	331	30	11,151	84	7
1983	2,977	35	12	24,793	242	27	20,744	174	21
1984	10,844	111	22	46,037	541	49	157,388	1,223	81
1985	780	9	2	33,471	259	37	68,923	460	58
1986	0	0	0	22,939	195	18	39,875	268	48
1987	4,045	26	5	43,093	352	29	2,665	26	8
1988	378	3	2	28,423	249	24	4,528	37	14
1989	0	0	0	7,424	57	8	0	0	0
1990	12,303	131	14	55,837	587	47	55	1	1
1991	0	1	1	26,035	211	32	24,025	194	26
1992	7,405	59	15	18,771	178	50	20,769	179	27
1993	13,471	130	15	13,264	137	34	22,022	185	30
1994	5,025	47	18	29,805	305	64	5,314	56	16
1995	29,070	324	34	2,963	212	31	1,922	19	7
1996	15,307	160	35	3,462	179	41	0	0	0
1997	17,239	189	33	64	122	26	77	1	1
1998	10,439	122	15	148	107	12	0	0	0
Total	146,752	1,619	255	403,256	4,647	600	381,371	2,922	348

Table 7. NRA pollock fishery average weight-at-age in kilograms. Shaded cells had missing observations and were filled with their mean values

Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1978	0.3318	0.3933	0.7603	0.6877	0.8097	0.9151	0.9065	0.9722	0.9281	1.0613	1.1674	1.1870	1.6149	1.0729
1979	0.2314	0.3476	0.5293	0.7306	0.6727	0.8250	0.9435	0.9532	1.0381	1.1638	1.0598	1.5186	1.5788	1.0206
1980	0.2392	0.5526	0.7651	0.8412	0.8629	0.9129	1.0002	1.0890	1.0628	1.0204	1.1568	1.1019	0.8521	1.5242
1981	0.3392	0.4778	0.5521	0.7286	0.7637	0.7817	0.8096	0.8953	0.9021	0.8598	1.0199	1.0259	0.8929	0.9079
1982	0.3392	0.4179	0.5414	0.6436	0.7838	0.8220	0.8417	0.8921	0.9842	1.0011	0.9575	0.9546	0.9058	0.9660
1983	0.3392	0.4736	0.6609	0.7333	0.7796	0.7954	0.9264	0.9574	1.0146	0.9024	1.1892	1.1496	0.9740	1.1400
1984	0.4260	0.4459	0.6609	0.7419	0.8099	0.8721	0.9680	0.9963	1.2704	1.6431	1.1351	1.2212	1.1943	1.1400
1985	0.4675	0.5656	0.6705	0.6896	0.8028	0.8536	0.8567	1.0909	1.2330	1.5996	1.6644	1.1496	1.6448	1.1400
1986	0.3392	0.5114	0.6019	0.7472	0.8266	0.8698	0.9506	0.9266	1.0137	0.9428	1.0702	0.8963	1.1943	1.1400
1987	0.3392	0.4736	0.6852	0.7562	0.8335	0.8504	0.8715	0.9809	1.0725	0.9915	1.3379	1.1546	1.0065	1.0935
1988	0.3392	0.4736	0.6609	0.8013	0.7905	0.8208	0.9279	0.8883	0.9839	0.8933	0.7843	0.7223	0.8976	1.0621
1989	0.3392	0.4736	0.6609	0.7536	0.8510	0.9260	0.9927	1.0611	1.1106	1.1501	1.1892	1.1496	1.1943	1.1400
1990	0.3392	0.4778	0.5521	0.7286	0.7637	0.7817	0.8096	0.8953	0.9021	0.8598	1.0199	1.0259	0.8929	0.9079
1991	0.3392	0.4736	0.6668	0.6551	0.7989	0.9620	1.0755	1.1731	1.0994	1.2177	1.1573	1.0955	1.2898	1.0856
1992	0.3392	0.4736	0.6401	0.7418	0.7254	0.7970	0.9356	1.2457	1.0267	1.0034	1.2501	1.1451	1.0514	1.0976
1993	0.3392	0.4736	0.8862	0.8237	1.0335	1.0315	1.1399	1.0808	1.1638	1.1905	1.2027	1.3256	1.1373	1.1352
1994	0.3392	0.4736	0.6373	0.8437	0.9743	1.1361	1.1400	1.1216	1.1907	1.2437	1.2659	1.0591	1.0900	1.1517
1995	0.3392	0.5512	0.8471	0.7536	1.1264	1.3303	1.3972	1.3551	1.4333	1.4197	1.5010	1.4466	1.6582	1.3206
1996	0.3392	0.5391	0.4753	0.9301	1.0287	1.1796	1.2751	1.3945	1.4682	1.3548	1.3777	1.3619	1.4562	1.3013
1997	0.3392	0.4736	0.6609	0.7536	0.8510	0.9260	0.9927	1.0611	1.1106	1.1501	1.1892	1.1496	1.1943	1.1400
1998	0.3392	0.4030	0.7631	0.7398	0.9826	1.0575	1.0850	1.2532	1.3137	1.4826	1.2785	1.3012	1.3597	1.4522
1999	0.3392	0.4736	0.6609	0.7536	0.8510	0.9260	0.9927	1.0611	1.1106	1.1501	1.1892	1.1496	1.1943	1.1400
2000	0.3392	0.4736	0.6609	0.7536	0.8510	0.9260	0.9927	1.0611	1.1106	1.1501	1.1892	1.1496	1.1943	1.1400
2001	0.3392	0.4736	0.6609	0.7536	0.8510	0.9260	0.9927	1.0611	1.1106	1.1501	1.1892	1.1496	1.1943	1.1400
2002	0.3392	0.4736	0.6609	0.7536	0.8510	0.9260	0.9927	1.0611	1.1106	1.1501	1.1892	1.1496	1.1943	1.1400
2003	0.3392	0.4736	0.6609	0.7536	0.8510	0.9260	0.9927	1.0611	1.1106	1.1501	1.1892	1.1496	1.1943	1.1400
2004	0.3392	0.4736	0.6609	0.7536	0.8510	0.9260	0.9927	1.0611	1.1106	1.1501	1.1892	1.1496	1.1943	1.1400
2005	0.3392	0.4736	0.6609	0.7536	0.8510	0.9260	0.9927	1.0611	1.1106	1.1501	1.1892	1.1496	1.1943	1.1400

Table 8. Number of aged and measured fish in the NRA pollock fishery used to estimate fishery age composition. Shaded values were not used in assessment.

	Number Aged			Number Measured		
Year	Males	Females	Total	Males	Females	Total
1978	209	322	531	490	1,013	1,503
1979	124	178	302	611	706	1,317
1980	93	167	260	971	1,183	2,154
1981	124	152	276	2,226	2,556	4,782
1982	564	640	1,204	3,655	4,058	7,713
1983	132	145	277	1,493	1,484	2,977
1984	294	312	606	5,273	5,571	10,844
1985	210	265	475	349	431	780
1986	77	113	190	0	0	0
1987	131	142	273	1,670	2,375	4,045
1988	34	33	67	188	190	378
1989	0	0	0	0	0	0
1990	46	49	95	5,209	7,094	12,303
1991	36	47	83	0	0	80
1992	110	121	231	3,755	3,650	7,405
1993	81	82	163	7,701	5,770	13,471
1994	157	151	308	2,644	2,381	5,025
1995	74	106	180	16,518	12,552	29,070
1996	95	84	179	8,933	6,374	15,307
1997	15	15	30	9,232	8,007	17,239
1998	144	170	314	5,992	4,447	10,439
1999	0	0	0	75	60	135
2000	0	1	1	70	114	184
2001	0	1	1	52	106	158
2002	0	0	0	46	61	107
2003	0	0	0	0	0	0
2004	0	0	0	153	212	365
2005	0	0	0	309	260	569

Table 9. Number of individual vessels and hauls sampled by observers in the NRA west of 174W longitude pollock fishery 1990-1998.

	NRA Area 541 West of 174W				NRA Area 542				NRA Area 543			
	Catcher Processor		Catcher Only		Catcher Processor		Catcher Only		Catcher Processor		Catcher Only	
Year	Vessels	Hauls	Vessels	Hauls	Vessels	Hauls	Vessels	Hauls	Vessels	Hauls	Vessels	Hauls
1990	12	50	0	0	16	132	0	0	2	4	0	0
1991	2	3	0	0	2	2	0	0	0	0	0	0
1992	18	126	0	0	4	5	0	0	0	0	0	0
1993	18	195	0	0	6	25	0	0	3	5	0	0
1994	18	76	0	0	3	6	0	0	0	0	0	0
1995	22	200	8	39	15	272	11	77	0	0	0	0
1996	5	12	7	15	25	198	10	38	0	0	0	0
1997	13	66	11	30	14	93	10	60	1	6	0	0
1998	4	6	5	16	3	24	5	19	2	97	4	24

Table 10. Estimated NRA region pollock catch at age (millions). Highest mode for each year is shaded.

Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1978	0.01	0.14	0.12	0.07	0.36	0.10	0.14	0.13	0.13	0.06	0.02	0.01		0.00	1.27
1979	0.01	2.18	2.22	2.02	2.43	1.73	0.65	0.63	0.37	0.03	0.22			0.05	12.53
1980	8.20	3.24	2.64	3.71	6.94	4.05	2.47	0.73	1.07	0.53	0.16	0.01	0.14	0.01	33.91
1981		5.72	3.36	2.19	1.65	2.55	2.54	1.93	1.37	0.73	0.20	0.15	0.20	0.04	22.64
1982		0.01	3.00	0.51	0.23	0.31	0.38	0.35	0.15	0.07	0.04	0.03	0.01	0.01	5.10
1983				0.74	0.44	0.17	0.11	0.24	0.23	0.05	0.04	0.01	0.00	0.00	2.04
1984	0.14	3.97		4.12	4.12	1.46	1.10	0.74	0.51	0.34	0.09	0.06	0.03	0.01	16.68
1985	0.01	0.01	0.17	0.06	0.17	0.46	0.20	0.08	0.08	0.04	0.01	0.01	0.00	0.00	1.30
1986															
1987			1.40	0.31	0.23	0.04	0.09	1.01	0.09	0.12	0.00	0.03	0.01	0.04	3.36
1988															
1989															
1990		0.95	0.26	0.96	0.78	0.78	0.93	0.17	1.10	0.34	0.56	0.28	0.13	0.21	7.45
1991															
1992			0.03	0.33	0.60	0.30	0.60	0.12	0.69	0.39	0.52	0.36	1.71	1.91	7.55
1993			0.18	0.47	1.12	1.34	0.54	1.46	0.81	0.88	0.83	0.38	0.70	4.34	13.05
1994			0.07	1.00	0.31	0.42	0.60	0.43	0.33	0.17	0.39	0.10	0.08	1.30	5.20
1995		0.22	0.38	0.00	10.22	1.19	5.10	4.84	1.42	2.36	2.08	3.82	0.77	8.32	40.71
1996		0.17	0.15	0.56	1.42	5.15	1.53	2.09	1.21	0.92	0.64	0.20	0.77	2.00	16.79
1997															
1998		0.05	0.08	5.66	1.65	1.05	0.96	1.71	1.20	1.00	2.40	1.30	1.17	1.49	19.73

Table 11. Pollock biomass estimates from the Aleutian Islands Groundfish Survey, 1980-2002.

	Aleutian Islands Region				
	NRA West (174W-170E)	NRA East (170W-174W)	NRA total	Unalaska-Umnak area (~165W-170W)	Combined
1980			243,695	56,732	300,427
1983			495,775	282,648	778,423
1986			439,461	102,379	541,840
1991	83,337	53,865	137,202	51,644	188,846
1994	47,623	29,879	77,502	39,696	117,199
1997	57,577	39,935	97,512	65,400	158,912
2000	76,613	28,985	105,598	22,462	128,060
2002	121,915	53,368	175,283	181,334	356,617
2004	19,201	111,250	130,451	235,658	366,110

Table 12. Results of the 2002 Aleutian Islands echo integration-trawl survey conducted by the R/V Kaiyo Maru.

	Leg 2-1	Leg 2-2	Leg 2-3	Leg 2-4
Area (km^2)	27,902	10,433	4,045	1,413
Density (mt/km^2)	2.18	1.82	2.46	1.79
Population (10^6)	37	12	6	2
Biomass (10^3 mt)	61	19	10	3
CV	0.31	0.33	0.21	0.76

Table 13. Estimated instantaneous natural mortality rates (M) by age from Wespestad and Terry (1984).

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
M	0.85	0.45	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6

Table 14. Estimated von Bertalanffy growth curve parameters and length-weight regression parameters for walleye pollock sampled during the U.S.-Japan 1980, 1983, and 1986 groundfish surveys and the 1991, 1994, 1997, 2000, and 2002 RACE groundfish surveys.

	L_{inf}	K	t_0	A	b
1980	51.92	0.414	-0.525	0.0132	2.858
1983	53.26	0.383	0.002	0.0178	2.768
1986	51.02	0.443	-0.084	0.0142	2.831
1991	54.55	0.392	-0.361	0.0104	2.912
1994	61.58	0.330	-0.102	0.0069	3.022
1997	61.41	0.286	-0.397	0.0081	2.983
2000	62.58	0.306	-0.048	0.0064	3.019
2002	64.36	0.289	-0.127	0.0066	3.018

Table 15. Average weight-at-age for Aleutian Islands pollock as estimated from NMFS summer bottom trawl survey estimates. Values between survey years (shaded) were set to the mean of the nearest two surveys (or single year for 1978-79, 2003-04).

	Age													
Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1978	0.31	0.50	0.65	0.78	0.87	0.93	0.97	1.00	1.02	1.03	1.04	1.04	1.05	1.05
1979	0.31	0.50	0.65	0.78	0.87	0.93	0.97	1.00	1.02	1.03	1.04	1.04	1.05	1.05
1980	0.31	0.50	0.65	0.78	0.87	0.93	0.97	1.00	1.02	1.03	1.04	1.04	1.05	1.05
1981	0.25	0.43	0.60	0.73	0.83	0.90	0.95	0.99	1.01	1.03	1.04	1.05	1.05	1.05
1982	0.25	0.43	0.60	0.73	0.83	0.90	0.95	0.99	1.01	1.03	1.04	1.05	1.05	1.05
1983	0.19	0.37	0.54	0.69	0.80	0.88	0.94	0.98	1.01	1.02	1.04	1.05	1.05	1.06
1984	0.21	0.40	0.56	0.70	0.80	0.87	0.92	0.95	0.97	0.99	1.00	1.01	1.01	1.01
1985	0.21	0.40	0.56	0.70	0.80	0.87	0.92	0.95	0.97	0.99	1.00	1.01	1.01	1.01
1986	0.23	0.42	0.59	0.71	0.80	0.86	0.90	0.92	0.94	0.95	0.96	0.96	0.97	0.97
1987	0.23	0.46	0.64	0.75	0.91	1.01	1.08	1.06	1.10	1.08	1.06	1.04	1.06	1.03
1988	0.23	0.46	0.64	0.75	0.91	1.01	1.08	1.06	1.10	1.08	1.06	1.04	1.06	1.03
1989	0.23	0.46	0.64	0.75	0.91	1.01	1.08	1.06	1.10	1.08	1.06	1.04	1.06	1.03
1990	0.23	0.46	0.64	0.75	0.91	1.01	1.08	1.06	1.10	1.08	1.06	1.04	1.06	1.03
1991	0.22	0.51	0.69	0.79	1.01	1.15	1.26	1.21	1.27	1.21	1.16	1.12	1.16	1.10
1992	0.21	0.51	0.78	0.89	1.08	1.22	1.25	1.33	1.36	1.32	1.35	1.33	1.35	1.22
1993	0.21	0.51	0.78	0.89	1.08	1.22	1.25	1.33	1.36	1.32	1.35	1.33	1.35	1.22
1994	0.20	0.52	0.87	1.00	1.14	1.29	1.24	1.45	1.44	1.43	1.54	1.54	1.54	1.35
1995	0.22	0.48	0.82	0.97	1.07	1.24	1.26	1.38	1.44	1.45	1.53	1.52	1.57	1.47
1996	0.22	0.48	0.82	0.97	1.07	1.24	1.26	1.38	1.44	1.45	1.53	1.52	1.57	1.47
1997	0.25	0.43	0.78	0.95	1.00	1.19	1.29	1.31	1.44	1.47	1.52	1.51	1.60	1.60
1998	0.21	0.47	0.77	0.92	0.95	1.17	1.28	1.31	1.43	1.50	1.62	1.59	1.53	1.65
1999	0.21	0.47	0.77	0.92	0.95	1.17	1.28	1.31	1.43	1.50	1.62	1.59	1.53	1.65
2000	0.17	0.51	0.77	0.89	0.90	1.15	1.26	1.32	1.41	1.52	1.71	1.67	1.47	1.70
2001	0.19	0.49	0.74	1.02	1.03	1.23	1.29	1.43	1.53	1.56	1.74	1.68	1.58	1.67
2002	0.21	0.47	0.70	1.15	1.16	1.32	1.32	1.53	1.65	1.61	1.76	1.69	1.68	1.64
2003	0.21	0.47	0.70	1.15	1.16	1.32	1.32	1.53	1.65	1.61	1.76	1.69	1.68	1.64
2004	0.22	0.46	0.70	0.83	0.96	1.21	1.15	1.38	1.48	1.55	1.63	1.65	1.55	1.68
2005	0.22	0.46	0.70	0.83	0.96	1.21	1.15	1.38	1.48	1.55	1.63	1.65	1.55	1.68

Table 16. Average weight-at-age for Aleutian Islands pollock as estimated from fishery data.

	Age													
Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1978	0.33	0.39	0.76	0.69	0.81	0.92	0.91	0.97	0.93	1.06	1.17	1.19	1.61	1.07
1979	0.23	0.35	0.53	0.73	0.67	0.83	0.94	0.95	1.04	1.16	1.06	1.52	1.58	1.02
1980	0.24	0.55	0.77	0.84	0.86	0.91	1.00	1.09	1.06	1.02	1.16	1.10	0.85	1.52
1981	0.34	0.48	0.55	0.73	0.76	0.78	0.81	0.90	0.90	0.86	1.02	1.03	0.89	0.91
1982	0.34	0.42	0.54	0.64	0.78	0.82	0.84	0.89	0.98	1.00	0.96	0.95	0.91	0.97
1983	0.34	0.47	0.66	0.73	0.78	0.80	0.93	0.96	1.01	0.90	1.19	1.15	0.97	1.14
1984	0.43	0.45	0.66	0.74	0.81	0.87	0.97	1.00	1.27	1.64	1.14	1.22	1.19	1.14
1985	0.47	0.57	0.67	0.69	0.80	0.85	0.86	1.09	1.23	1.60	1.66	1.15	1.64	1.14
1986	0.34	0.51	0.60	0.75	0.83	0.87	0.95	0.93	1.01	0.94	1.07	0.90	1.19	1.14
1987	0.34	0.47	0.69	0.76	0.83	0.85	0.87	0.98	1.07	0.99	1.34	1.15	1.01	1.09
1988	0.34	0.47	0.66	0.80	0.79	0.82	0.93	0.89	0.98	0.89	0.78	0.72	0.90	1.06
1989	0.34	0.47	0.66	0.75	0.85	0.93	0.99	1.06	1.11	1.15	1.19	1.15	1.19	1.14
1990	0.34	0.48	0.55	0.73	0.76	0.78	0.81	0.90	0.90	0.86	1.02	1.03	0.89	0.91
1991	0.34	0.47	0.67	0.66	0.80	0.96	1.08	1.17	1.10	1.22	1.16	1.10	1.29	1.09
1992	0.34	0.47	0.64	0.74	0.73	0.80	0.94	1.25	1.03	1.00	1.25	1.15	1.05	1.10
1993	0.34	0.47	0.89	0.82	1.03	1.03	1.14	1.08	1.16	1.19	1.20	1.33	1.14	1.14
1994	0.34	0.47	0.64	0.84	0.97	1.14	1.14	1.12	1.19	1.24	1.27	1.06	1.09	1.15
1995	0.34	0.55	0.85	0.75	1.13	1.33	1.40	1.36	1.43	1.42	1.50	1.45	1.66	1.32
1996	0.34	0.54	0.48	0.93	1.03	1.18	1.28	1.39	1.47	1.35	1.38	1.36	1.46	1.30
1997	0.34	0.47	0.66	0.75	0.85	0.93	0.99	1.06	1.11	1.15	1.19	1.15	1.19	1.14
1998	0.34	0.40	0.76	0.74	0.98	1.06	1.09	1.25	1.31	1.48	1.28	1.30	1.36	1.45
1999	0.34	0.47	0.66	0.75	0.85	0.93	0.99	1.06	1.11	1.15	1.19	1.15	1.19	1.14
2000	0.34	0.47	0.66	0.75	0.85	0.93	0.99	1.06	1.11	1.15	1.19	1.15	1.19	1.14
2001	0.34	0.47	0.66	0.75	0.85	0.93	0.99	1.06	1.11	1.15	1.19	1.15	1.19	1.14
2002	0.34	0.47	0.66	0.75	0.85	0.93	0.99	1.06	1.11	1.15	1.19	1.15	1.19	1.14
2003	0.33	0.39	0.76	0.69	0.81	0.92	0.91	0.97	0.93	1.06	1.17	1.19	1.61	1.07
2004	0.33	0.39	0.76	0.69	0.81	0.92	0.91	0.97	0.93	1.06	1.17	1.19	1.61	1.07
2005	0.33	0.39	0.76	0.69	0.81	0.92	0.91	0.97	0.93	1.06	1.17	1.19	1.61	1.07

Table 17. Percentage mature females at age from Wespestad and Terry (1984).

Age	1	2	3	4	5	6	7	8	9	10	11	12	13-16
Percent	0.0	0.8	28.9	64.1	84.2	90.1	94.7	96.3	97.0	97.8	98.4	99.0	100.0

Table 18. Comparisons of fits for the evaluations of Aleutian Islands pollock Model 1 and Model 2.

	Model 1	**Model 2**
Number of Parameters	265	265
Survey catchability	1.00	1.00
Fishery Average Effective N	39.95	42.85
Survey Average Effective N	211.16	205.73
RMSE Survey	0.65	0.36
-log Likelihoods		
Survey index	24.15	8.14
Fishery age comp	79.71	72.26
Survey age comp	22.32	20.50
Sub total	126.19	100.91
-log Penalties		
Recruitment	-7.45	-12.89
Selectivity constraint	13.77	14.57
Prior	0.00	0.00
Total	142.90	111.92

Table 19. Key results for the evaluations of Aleutian Islands pollock Model 1 and Model 2.

	Model 1	**Model 2**
Model conditions		
Survey catchability	1.00	1.00
Natural mortality	0.30	0.30
Fishing mortalities		
Max F 1978-2005	0.49	0.35
F 2005	0.03	0.02
Stock abundance		
Initial Biomass (1978; thousands of tons)	451.42	593.75
CV	23%	23%
2005 total biomass (thousands of tons)	218.11	468.90
CV	22%	21%
2006 Age 3+ biomass (thousands of tons)	180.12	362.06
1978 year class (at age 2)	159.36	198.57
CV	30%	30%
Recruitment Variability	0.58	0.43
Specified Sigma R	0.60	0.60
Steepness (h)	0.56	0.70
Projected catch (unadjusted)		
F50% 2006 catch	25.93	76.64
CV	22%	22%
F40% 2006 catch	39.57	114.78
CV	22%	23%
F35% 2006 catch	48.90	138.57
CV	22%	23%

Table 20. Model 1 (left) and Model 2(left) estimates of pollock biomass with approximate lower and upper 95% confidence bounds for age 2+ biomass. Also included is the age 3+ biomass.

M1 Year	Total Biomass (age 2+)	LCI	UCI	Biomass Age 3+
1978	451,420	248,100	654,740	346,718
1979	462,640	268,032	657,248	310,089
1980	560,130	356,690	763,570	392,453
1981	579,320	375,760	782,880	481,061
1982	577,240	382,098	772,382	428,867
1983	570,810	391,756	749,864	433,044
1984	548,580	390,698	706,462	418,901
1985	511,060	374,806	647,314	399,458
1986	481,630	365,962	597,298	359,779
1987	446,370	349,496	543,244	339,733
1988	417,930	337,188	498,672	293,789
1989	397,830	330,276	465,384	306,042
1990	381,900	324,692	439,108	261,828
1991	375,070	327,084	423,056	271,975
1992	374,990	333,678	416,302	295,060
1993	352,350	316,322	388,378	334,127
1994	314,420	282,540	346,300	272,443
1995	286,870	257,460	316,280	281,890
1996	205,890	177,620	234,160	190,262
1997	171,440	142,610	200,270	132,903
1998	135,190	103,942	166,438	112,160
1999	110,260	76,322	144,198	90,183
2000	117,700	79,690	155,710	91,899
2001	127,430	83,298	171,562	98,202
2002	145,910	90,766	201,054	109,301
2003	163,070	98,244	227,896	132,354
2004	177,800	104,744	250,856	143,503
2005	201,860	116,600	287,120	152,123
2006	218,110	122,710	313,510	180,121

M2 Year	Total Biomass (age 2+)	LCI	UCI	Biomass Age 3+
1978	593,750	319,750	867,750	440,774
1979	602,850	343,450	862,250	393,174
1980	729,740	461,280	998,200	495,996
1981	784,820	512,460	1,057,180	608,613
1982	796,100	532,960	1,059,240	546,478
1983	761,350	527,510	995,190	552,772
1984	709,120	509,844	908,396	535,648
1985	664,100	492,806	835,394	513,602
1986	622,140	478,374	765,906	462,715
1987	579,980	458,994	700,966	438,305
1988	543,800	442,692	644,908	380,879
1989	517,020	431,478	602,562	396,944
1990	499,390	424,184	574,596	338,974
1991	496,990	428,128	565,852	354,618
1992	501,290	434,748	567,832	382,160
1993	482,140	416,078	548,202	437,346
1994	440,180	375,268	505,092	368,065
1995	412,740	346,774	478,706	395,838
1996	340,780	271,558	410,002	305,286
1997	315,710	240,428	390,992	238,941
1998	293,920	208,788	379,052	234,001
1999	279,840	185,174	374,506	217,816
2000	299,310	192,216	406,404	222,476
2001	326,460	201,836	451,084	240,193
2002	381,690	223,848	539,532	271,575
2003	425,020	242,106	607,934	335,009
2004	449,700	254,208	645,192	350,695
2005	464,120	264,408	663,832	347,883
2006	468,900	268,994	668,806	362,057

Table 21. Estimated pollock numbers at age in millions. 1978-2005 based on Model 1 (top) and Model 2 (bottom).

Model 1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	**% of 15+**
1978	159	129	107	75	64	28	23	17	13	9	6	4	3	8	646	1.30%
1979	215	118	95	78	55	47	20	17	12	9	7	4	3	9	690	1.24%
1980	681	159	86	69	56	39	33	14	12	8	7	5	3	8	1180	0.70%
1981	156	500	114	60	47	36	25	20	8	7	5	4	3	7	994	0.73%
1982	94	115	365	81	42	32	25	16	13	6	5	4	3	7	808	0.86%
1983	160	70	85	266	59	31	23	18	12	10	4	3	3	7	750	0.95%
1984	150	119	51	62	195	43	22	17	13	8	7	3	2	7	700	1.00%
1985	141	111	87	37	45	139	31	16	12	9	6	5	2	7	646	1.03%
1986	122	104	82	64	27	33	101	22	11	8	6	4	4	6	596	1.06%
1987	93	90	77	60	47	20	24	74	16	8	6	5	3	7	530	1.35%
1988	142	69	66	56	44	34	14	17	53	11	6	4	3	7	528	1.39%
1989	130	105	51	49	41	32	25	11	12	38	8	4	3	8	518	1.50%
1990	118	96	78	38	36	30	24	18	8	9	28	6	3	8	499	1.59%
1991	226	87	71	56	27	25	21	16	12	5	6	19	4	7	582	1.26%
1992	100	168	65	52	41	20	18	15	12	9	4	4	13	8	529	1.55%
1993	69	74	124	47	38	30	14	13	11	8	6	2	3	14	452	3.08%
1994	60	51	54	90	34	26	20	9	8	7	5	4	1	10	380	2.54%
1995	63	45	38	40	66	24	19	14	6	6	5	4	2	7	339	2.18%
1996	43	47	32	27	26	37	12	9	7	3	3	2	1	3	252	1.17%
1997	54	32	34	23	18	16	22	7	5	4	2	1	1	2	223	0.84%
1998	60	40	23	24	15	10	8	10	3	3	2	1	0	1	201	0.45%
1999	43	44	29	16	15	8	5	3	5	2	1	1	0	0	172	0.22%
2000	61	32	33	21	12	11	6	3	3	3	1	1	0	0	187	0.22%
2001	74	45	24	24	16	9	8	4	2	2	2	1	1	1	212	0.30%
2002	111	55	34	17	18	11	6	6	3	2	1	2	1	1	267	0.32%
2003	84	82	41	25	13	13	8	4	4	2	1	1	1	1	280	0.37%
2004	88	62	61	30	18	9	9	6	3	3	1	1	1	2	294	0.53%
2005	148	65	46	45	22	13	7	7	4	2	2	1	1	2	363	0.42%

Model 2	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	**% of 15+**
1978	199	161	133	93	81	35	30	22	17	12	8	6	4	13	814	1.59%
1979	267	147	119	97	68	59	26	22	16	12	9	6	4	13	864	1.47%
1980	847	197	108	86	70	48	41	18	15	11	9	6	4	12	1474	0.82%
1981	199	623	143	76	59	47	32	27	11	10	7	6	4	11	1254	0.85%
1982	123	147	456	102	54	42	32	22	18	8	7	5	4	10	1028	1.00%
1983	205	91	108	333	74	39	30	23	16	13	6	5	4	10	957	1.08%
1984	193	152	67	80	243	54	28	22	17	11	9	4	3	10	895	1.13%
1985	183	143	112	49	57	175	39	20	15	12	8	7	3	10	831	1.16%
1986	160	135	106	82	36	42	127	28	15	11	9	6	5	9	769	1.18%
1987	123	118	100	78	60	26	31	93	20	11	8	6	4	10	687	1.47%
1988	184	91	87	73	57	44	19	22	67	15	8	6	4	10	686	1.49%
1989	167	136	67	64	54	42	32	14	16	48	11	5	4	11	670	1.59%
1990	151	123	101	49	47	39	30	23	10	12	35	8	4	11	644	1.67%
1991	288	111	91	73	35	33	28	21	16	7	8	24	5	10	751	1.33%
1992	138	213	82	67	54	26	25	20	15	12	5	6	17	11	691	1.59%
1993	108	102	158	61	49	39	19	17	14	11	8	3	4	19	610	3.04%
1994	108	80	75	116	44	35	27	13	12	10	7	5	2	13	546	2.45%
1995	133	80	59	55	85	32	25	19	9	8	7	5	3	10	531	1.95%
1996	97	98	59	42	38	53	19	14	11	5	4	3	2	4	448	1.00%
1997	125	72	72	43	30	26	35	12	9	7	3	2	1	3	439	0.69%
1998	143	93	52	52	29	19	16	21	7	5	4	1	1	2	444	0.38%
1999	103	106	68	38	36	19	12	9	12	4	3	2	1	1	412	0.24%
2000	152	76	78	50	28	26	14	9	7	9	3	2	1	1	455	0.24%
2001	191	112	56	58	37	20	19	10	6	5	6	2	1	2	526	0.31%
2002	289	141	83	42	43	27	15	14	7	5	4	5	1	2	678	0.32%
2003	164	214	105	61	31	31	20	11	10	5	3	3	3	3	664	0.39%
2004	148	121	159	77	45	23	23	15	8	7	4	2	2	4	639	0.67%
2005	202	109	90	117	57	33	17	17	11	6	5	3	2	4	672	0.65%

Table 22. Estimates of full-selection fishing mortality and exploitation rates for pollock based on Model1 (left) and Model 2 (right).

Model 1

Year	F[a]	Catch/Biomass Rate[b]
1978	0.017	0.003
1979	0.047	0.026
1980	0.127	0.076
1981	0.076	0.031
1982	0.024	0.007
1983	0.019	0.004
1984	0.043	0.022
1985	0.016	0.002
1986	0.016	0.002
1987	0.024	0.008
1988	0.016	0.002
1989	0.013	0.000
1990	0.074	0.040
1991	0.013	0.002
1992	0.068	0.029
1993	0.118	0.048
1994	0.052	0.022
1995	0.423	0.206
1996	0.231	0.122
1997	0.405	0.194
1998	0.490	0.208
1999	0.026	0.007
2000	0.031	0.010
2001	0.023	0.006
2002	0.018	0.003
2003	0.036	0.011
2004	0.038	0.011
2005	0.034	0.010

[a] Full selection fishing mortality rates.
[b] Catch/biomass rate is the ratio of catch to beginning year age 3+ biomass.

Model 2

Year	F[a]	Catch/Biomass Rate[b]
1978	0.016	0.002
1979	0.039	0.020
1980	0.100	0.060
1981	0.061	0.024
1982	0.022	0.006
1983	0.017	0.003
1984	0.036	0.017
1985	0.016	0.002
1986	0.015	0.002
1987	0.022	0.006
1988	0.015	0.001
1989	0.013	0.000
1990	0.061	0.031
1991	0.012	0.002
1992	0.055	0.022
1993	0.095	0.037
1994	0.042	0.016
1995	0.347	0.147
1996	0.175	0.076
1997	0.288	0.108
1998	0.272	0.100
1999	0.017	0.003
2000	0.019	0.004
2001	0.015	0.002
2002	0.013	0.001
2003	0.011	0.004
2004	0.022	0.005
2005	0.020	0.004

[a] Full selection fishing mortality rates.
[b] Catch/biomass rate is the ratio of catch to beginning year age 3+ biomass.

Table 23. Estimates of age-2 pollock recruitment (in millions) based on Model 1 and Model 2.Model 1.

Model 1

Year class	Index at age 2
1976	159.4
1977	215.5
1978	681.3
1979	155.7
1980	94.3
1981	160.5
1982	150.4
1983	140.9
1984	121.6
1985	93.3
1986	141.9
1987	130.2
1988	118.2
1989	226.4
1990	99.9
1991	69.1
1992	60.3
1993	63.4
1994	43.1
1995	54.2
1996	60.5
1997	43.0
1998	61.2
1999	74.3
2000	110.8
2001	83.7
2002	87.9
2003	147.5
Ave 83-03	96.7
Med 83-03	87.9

Model 2

Year class	Index at age 2
1976	198.6
1977	266.8
1978	847.3
1979	199.2
1980	123.1
1981	205.4
1982	193.3
1983	182.8
1984	159.7
1985	122.7
1986	183.9
1987	166.8
1988	150.7
1989	288.1
1990	137.6
1991	107.7
1992	108.3
1993	132.8
1994	96.8
1995	125.5
1996	142.9
1997	103.0
1998	151.6
1999	190.6
2000	289.3
2001	163.6
2002	147.7
2003	201.7
Ave 83-03	159.7
Med 83-03	150.7

Table 24. Results from MCMC simulations with 1 million iterations sampled every 200th iteration for reference Model 1 and reference Model 2.

Model 1

Parameter	Mean	CV
Steepness	0.55	35%
Depletion	0.46	25%
2005 Total Biomass	222.57	23%
$F_{35\%}$	1.63	22%
$F_{40\%}$	1.22	20%
$F_{50\%}$	0.72	18%

Model 2

Parameter	Mean	CV
Steepness	0.66	26%
Depletion	0.83	25%
2005 Total Biomass	487.57	22%
$F_{35\%}$	3.31	24%
$F_{40\%}$	2.44	23%
$F_{50\%}$	1.38	22%

Table 25 Estimates of 2005 pollock fishery, survey, and projected fishery selectivity-at-age for Model 1 and Model 2.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
M1 Fishery	0.012	0.031	0.090	0.276	0.451	0.587	0.666	0.632	0.611	0.617	0.788	1.000	1.000	1.000
M2 Fishery	0.008	0.020	0.055	0.160	0.260	0.347	0.422	0.447	0.486	0.558	0.769	1.000	1.000	1.000
Projected*	0.016	0.110	0.438	0.949	1.470	1.639	1.621	1.470	1.290	1.198	1.198	1.198	1.198	1.198
M1 Survey	0.022	0.068	0.171	0.265	0.342	0.421	0.534	0.713	0.984	1.302	1.488	1.536	1.536	1.536
M2 Survey	0.026	0.083	0.211	0.329	0.428	0.522	0.634	0.764	0.966	1.270	1.585	1.728	1.728	1.728

* From the 2004 EBS pollock stock assessment (Ianelli et al. 2004).

Table 26. Projections of Model 1 (with adjusted selectivity) spawning biomass (in thousands of mt), *F*, and catch (in thousands of mt) for NRA pollock for the 8 scenarios. Fishing mortality rates given are based on the *average* fishing mortality over all ages.

Sp.Biomass	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*	*Scenario 8*
2005	64.20	64.20	64.20	64.20	64.20	64.20	64.20	64.20
2006	66.18	66.18	68.34	70.16	70.59	65.03	66.18	68.37
2007	58.69	58.69	69.08	79.53	82.21	53.95	58.69	69.25
2008	55.94	55.94	70.69	87.97	92.80	50.14	55.14	70.96
2009	55.14	55.14	72.28	95.18	102.06	49.49	51.39	72.71
2010	54.69	54.69	72.82	100.12	108.83	49.18	49.82	73.73
2011	54.34	54.34	72.94	103.73	114.09	48.88	49.08	74.44
2012	53.76	53.76	72.59	106.00	117.76	48.36	48.42	74.58
2013	53.39	53.39	72.26	107.53	120.44	48.06	48.08	74.56
2014	53.42	53.42	72.25	108.82	122.61	48.13	48.14	74.72
2015	53.57	53.57	72.39	109.88	124.38	48.32	48.32	74.97
2016	53.94	53.94	72.77	110.95	125.99	48.67	48.67	75.43
2017	53.66	53.66	72.51	111.21	126.68	48.36	48.36	75.28
2018	53.32	53.32	72.20	111.27	127.07	48.02	48.02	75.03
F	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*	*Scenario 8*
2005	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2006	0.32	0.32	0.16	0.03	0.00	0.41	0.32	0.16
2007	0.32	0.32	0.16	0.03	0.00	0.41	0.32	0.16
2008	0.32	0.32	0.16	0.03	0.00	0.38	0.40	0.16
2009	0.30	0.30	0.16	0.03	0.00	0.36	0.37	0.16
2010	0.30	0.30	0.16	0.03	0.00	0.36	0.36	0.16
2011	0.30	0.30	0.16	0.03	0.00	0.36	0.36	0.16
2012	0.30	0.30	0.16	0.03	0.00	0.36	0.36	0.16
2013	0.30	0.30	0.16	0.03	0.00	0.36	0.36	0.17
2014	0.30	0.30	0.16	0.03	0.00	0.36	0.36	0.17
2015	0.30	0.30	0.16	0.03	0.00	0.36	0.36	0.17
2016	0.30	0.30	0.16	0.03	0.00	0.36	0.36	0.17
2017	0.30	0.30	0.16	0.03	0.00	0.36	0.36	0.17
2018	0.30	0.30	0.16	0.03	0.00	0.36	0.36	0.17
Catch	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*	*Scenario 8*
2005	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56
2006	35.29	35.29	19.25	3.85	0.00	42.91	35.29	19.00
2007	30.84	30.84	19.25	4.35	0.00	35.08	30.84	19.00
2008	28.38	28.38	19.30	4.73	0.00	29.98	34.59	19.00
2009	27.36	27.36	19.86	5.14	0.00	29.02	30.73	19.00
2010	27.16	27.16	20.24	5.48	0.00	28.95	29.49	19.00
2011	26.97	26.97	20.27	5.68	0.00	28.76	28.91	19.00
2012	26.66	26.66	20.17	5.79	0.00	28.38	28.42	19.00
2013	26.43	26.43	20.02	5.84	0.00	28.19	28.19	19.00
2014	26.43	26.43	19.99	5.90	0.00	28.20	28.20	19.00
2015	26.47	26.47	20.01	5.93	0.00	28.29	28.29	19.00
2016	26.61	26.61	20.09	5.97	0.00	28.48	28.48	19.00
2017	26.55	26.55	20.07	6.00	0.00	28.35	28.35	19.00
2018	26.34	26.34	19.97	6.00	0.00	28.06	28.06	19.00

Table 27. Projections of Model 2 (with adjusted selectivity) spawning biomass (in thousands of mt), *F*, and catch (in thousands of mt) for NRA pollock for the 8 scenarios. Fishing mortality rates given are based on the *average* fishing mortality over all ages.

Sp.Biomass	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*	*Scenario 8*
2005	172.28	172.28	172.28	172.28	172.28	172.28	172.28	172.28
2006	174.43	174.43	180.96	186.64	187.76	170.81	174.43	185.62
2007	120.79	120.79	148.86	179.15	185.84	107.78	120.79	173.21
2008	94.93	94.93	129.81	175.68	186.99	81.24	93.09	165.73
2009	83.63	83.63	118.56	172.99	187.78	71.99	76.56	159.65
2010	80.15	80.15	112.94	171.44	188.61	70.76	72.08	155.33
2011	79.10	79.10	109.91	170.51	189.36	70.68	71.01	152.05
2012	78.15	78.15	107.52	169.13	189.18	70.14	70.22	148.87
2013	77.61	77.61	105.92	167.85	188.72	69.80	69.82	146.26
2014	77.35	77.35	104.96	166.95	188.43	69.67	69.68	144.34
2015	77.27	77.27	104.40	166.26	188.15	69.66	69.67	142.86
2016	77.83	77.83	104.66	166.39	188.56	70.25	70.25	142.30
2017	77.66	77.66	104.36	165.99	188.36	70.03	70.03	141.37
2018	77.29	77.29	103.94	165.48	188.01	69.64	69.64	140.42
F	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*	*Scenario 8*
2005	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2006	0.37	0.37	0.19	0.03	0.00	0.48	0.37	0.06
2007	0.37	0.37	0.19	0.03	0.00	0.48	0.37	0.06
2008	0.37	0.37	0.19	0.03	0.00	0.47	0.48	0.06
2009	0.36	0.36	0.19	0.03	0.00	0.43	0.45	0.07
2010	0.35	0.35	0.19	0.03	0.00	0.42	0.43	0.07
2011	0.35	0.35	0.19	0.03	0.00	0.42	0.42	0.07
2012	0.35	0.35	0.19	0.03	0.00	0.42	0.42	0.08
2013	0.35	0.35	0.18	0.03	0.00	0.42	0.42	0.08
2014	0.35	0.35	0.18	0.03	0.00	0.42	0.42	0.08
2015	0.35	0.35	0.19	0.03	0.00	0.42	0.42	0.08
2016	0.35	0.35	0.19	0.03	0.00	0.42	0.42	0.08
2017	0.35	0.35	0.19	0.03	0.00	0.42	0.42	0.08
2018	0.35	0.35	0.18	0.03	0.00	0.42	0.42	0.08
Catch	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*	*Scenario 8*
2005	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56
2006	102.59	102.59	56.87	10.05	0.00	124.78	102.59	19.00
2007	72.61	72.61	48.64	10.21	0.00	79.85	72.61	19.00
2008	55.26	55.26	41.43	9.87	0.00	57.40	67.47	19.00
2009	46.15	46.15	36.81	9.48	0.00	45.96	50.81	19.00
2010	42.66	42.66	34.28	9.14	0.00	44.21	45.55	19.00
2011	42.02	42.02	33.39	9.10	0.00	44.25	44.57	19.00
2012	41.50	41.50	32.77	9.06	0.00	43.96	44.01	19.00
2013	41.29	41.29	32.41	9.08	0.00	43.75	43.76	19.00
2014	41.10	41.10	32.12	9.07	0.00	43.65	43.66	19.00
2015	40.97	40.97	31.87	8.95	0.00	43.55	43.55	19.00
2016	41.19	41.19	31.90	8.96	0.00	43.90	43.90	19.00
2017	41.18	41.18	31.81	8.92	0.00	43.87	43.87	19.00
2018	40.98	40.98	31.73	8.92	0.00	43.59	43.59	19.00

Table 28. **Ecosystem effects on AI walleye pollock**

Indicator	Observation	Interpretation	Evaluation
Prey availability or abundance trends			
Zooplankton	Stomach contents, ichthyoplankton surveys	None	Unknown
Predator population trends			
Marine mammals	Fur seals declining, Steller sea lions increasing slightly	Possibly lower mortality on walleye pollock	No concern
Birds	Stable, some increasing some decreasing	May affect young-of-year mortality	Unknown
Fish (Pacific cod, arrowtooth flounder)	Pacific cod—decreasing, arrowtooth--stable	Possible decreases to walleye pollock mortality	No concern
Changes in habitat quality			
Temperature regime	The 2004 AI summer bottom temperature was near average. A warming since 2000 and 2002 were coldest and second coldest survey years respectively.	Warming from 2002 could affect apparent distribution.	Unknown

***The AI walleye pollock* effects on ecosystem**

Indicator	Observation	Interpretation	Evaluation
Fishery contribution to bycatch			
Prohibited species	Expected to be heavily monitored	Likely to be a minor contribution to mortality	No concern
Forage (including herring, Atka mackerel, cod, and pollock)	Expected to be heavily monitored.	Bycatch levels should be low.	Unknown
HAPC biota (seapens/whips, corals, sponges, anemones)	Very low bycatch levels of seapens/whips, sponge and coral catches expected in the pelagic fishery	Bycatch levels and destruction of benthic habitat expected to be minor given the pelagic fishery.	No concern
Marine mammals and birds	Very minor direct-take expected	Likely to be very minor contribution to mortality	No concern
Sensitive non-target species	Expected to be heavily monitored	Unknown given that this fishery was closed between 1999 and 2005. The 2005 fishery had a high bycatch of POP, but bycatch of other species was very low in fishery prior to 1999.	No concern
Other non-target species	Very little bycatch.	Unknown	No concern
Fishery concentration in space and time	Steller sea lion protection measures may concentrate fishery spatially to very small areas between 20 nm closures	Depending on concentration of pollock outside of critical habitat could possibly have an effect.	Possible concern
Fishery effects on amount of large size target fish	Depends on highly variable year-class strength	Natural fluctuation	Possible Concern
Fishery contribution to discards and offal production	Offal production—unknown. Fishery in 2005 expected to be conducted by CPs which may have fish meal production capabilities	Unknown	Unknown
Fishery effects on age-at-maturity and fecundity	Unknown	Unknown	Unknown

Figures

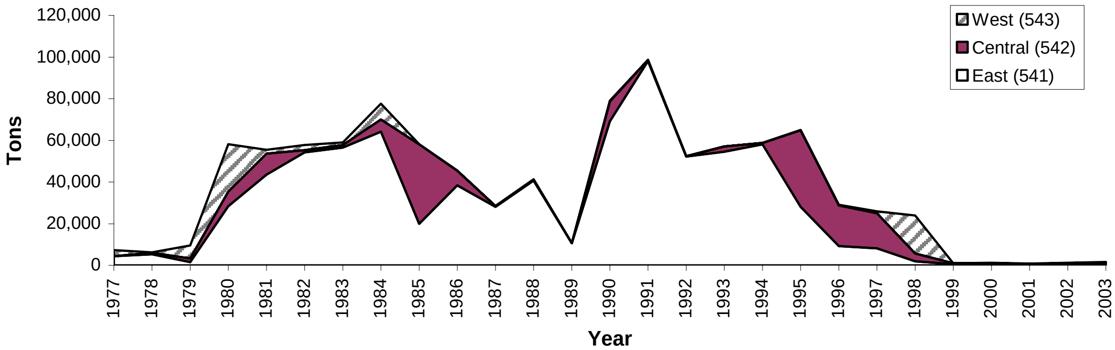


Figure 1. Estimated pollock catch by sub-area of the Aleutian Islands Region, 1977-2003. Units in metric tons.

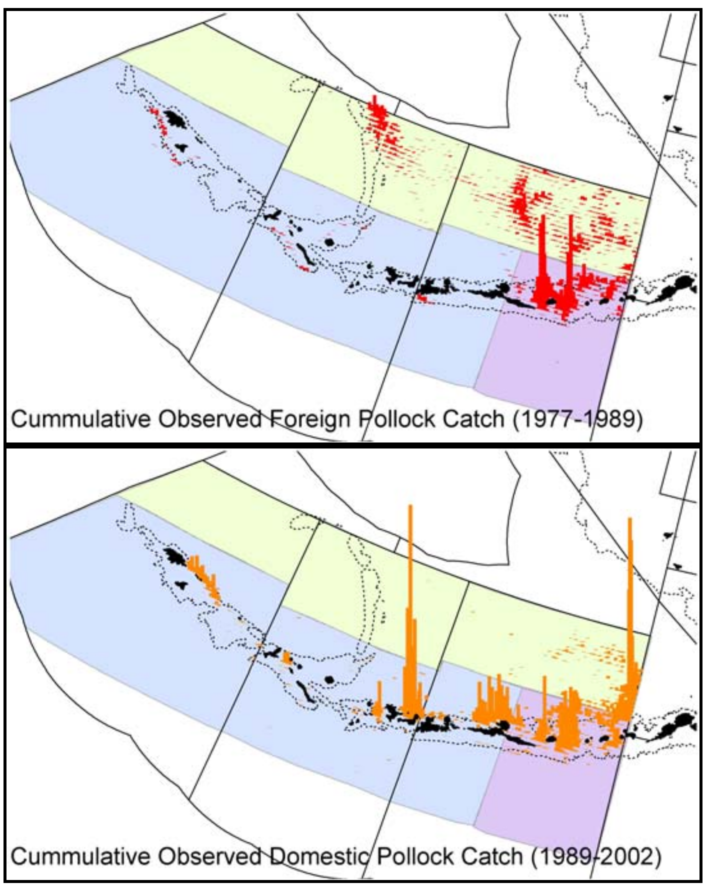


Figure 2. Observed foreign and J.V. (1978-1989), and domestic (1989-2002) pollock catch in the Aleutian Islands Area summed over all years and 10 minute latitude and longitude blocks. Both maps use the same scale (maximum observed catch per 10 minute block: foreign and J.V. 8,000 t and Domestic 19,000 t). Catches of less than 1 t were excluded from cumulative totals.

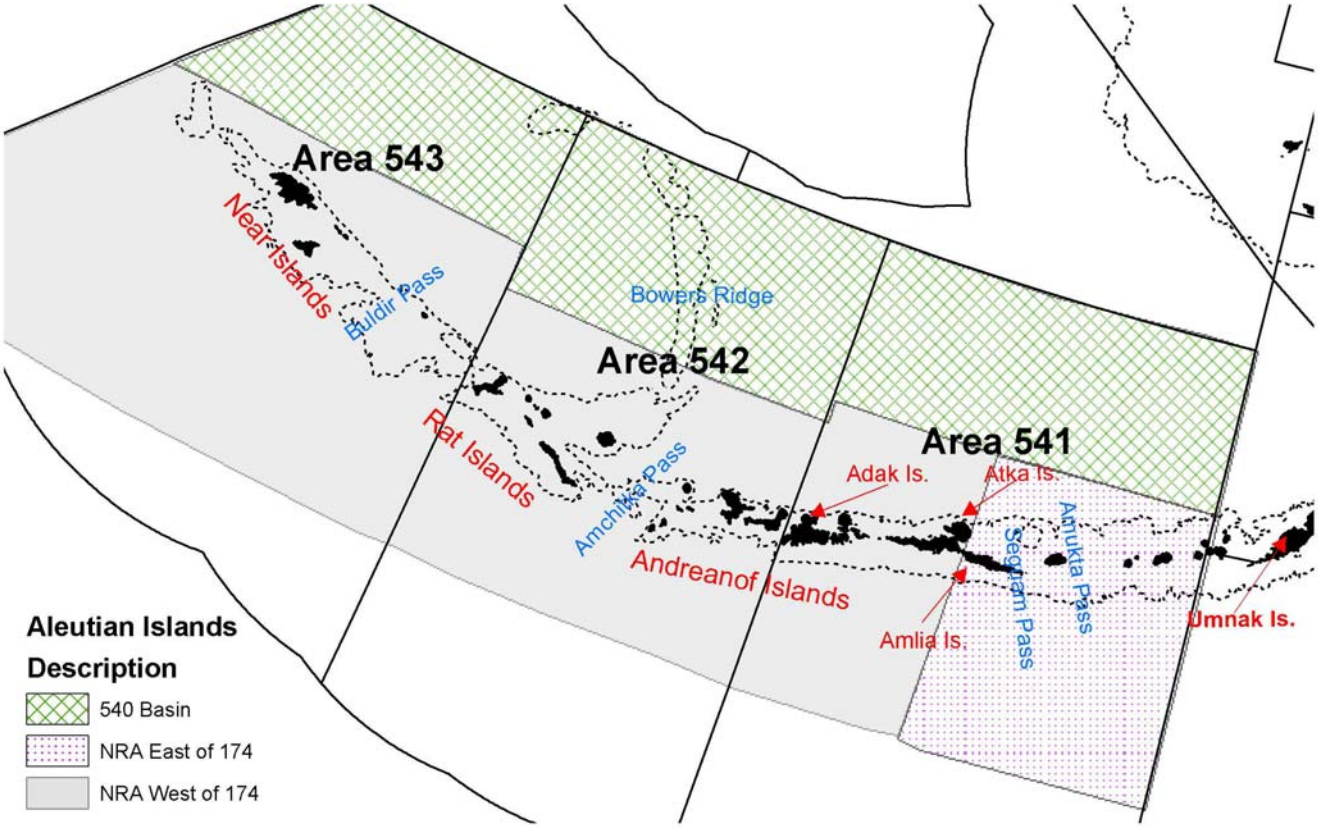


Figure 3. Regions defined for consideration of alternative data partitions for Aleutian Islands Region pollock. The abbreviation "NRA" represents the Near, Rat, and Andreanof Island groups.

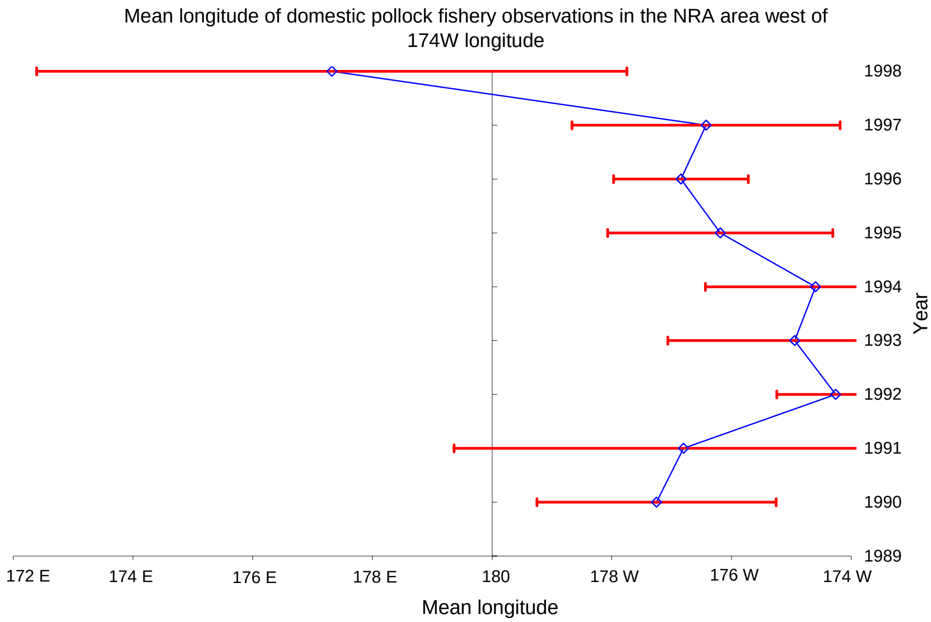


Figure 4. Mean longitude of observed targeted domestic (1990-1998) pollock catch in the NRA west of 174 W longitude. Error bars indicate one standard deviation from the mean.

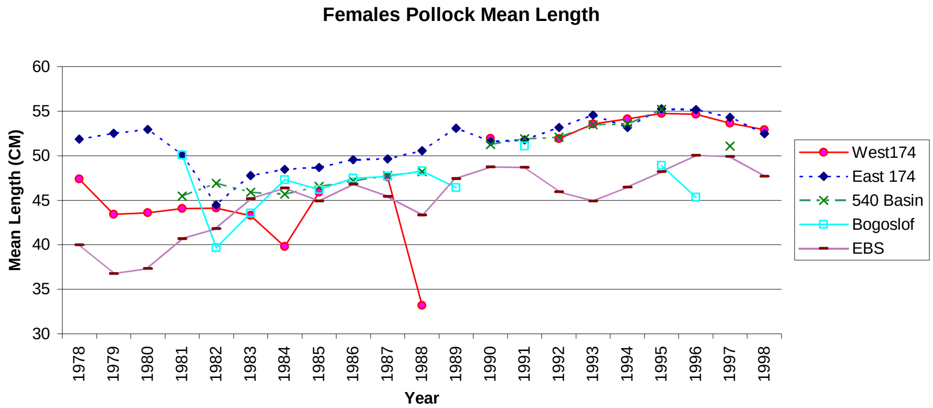


Figure 5. Mean length of female pollock for various areas from observer data.

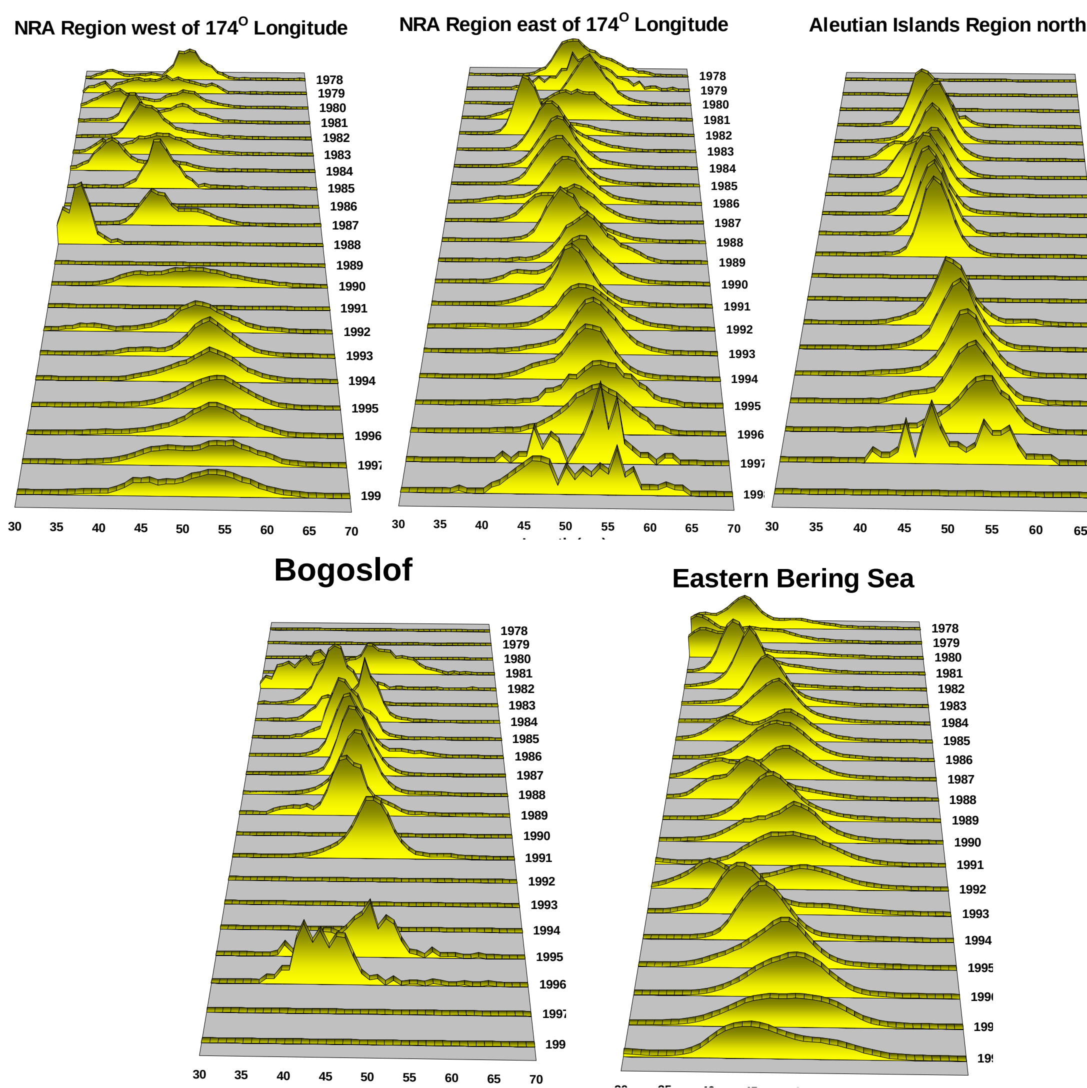


Figure 6. Pollock length frequency distributions by region.

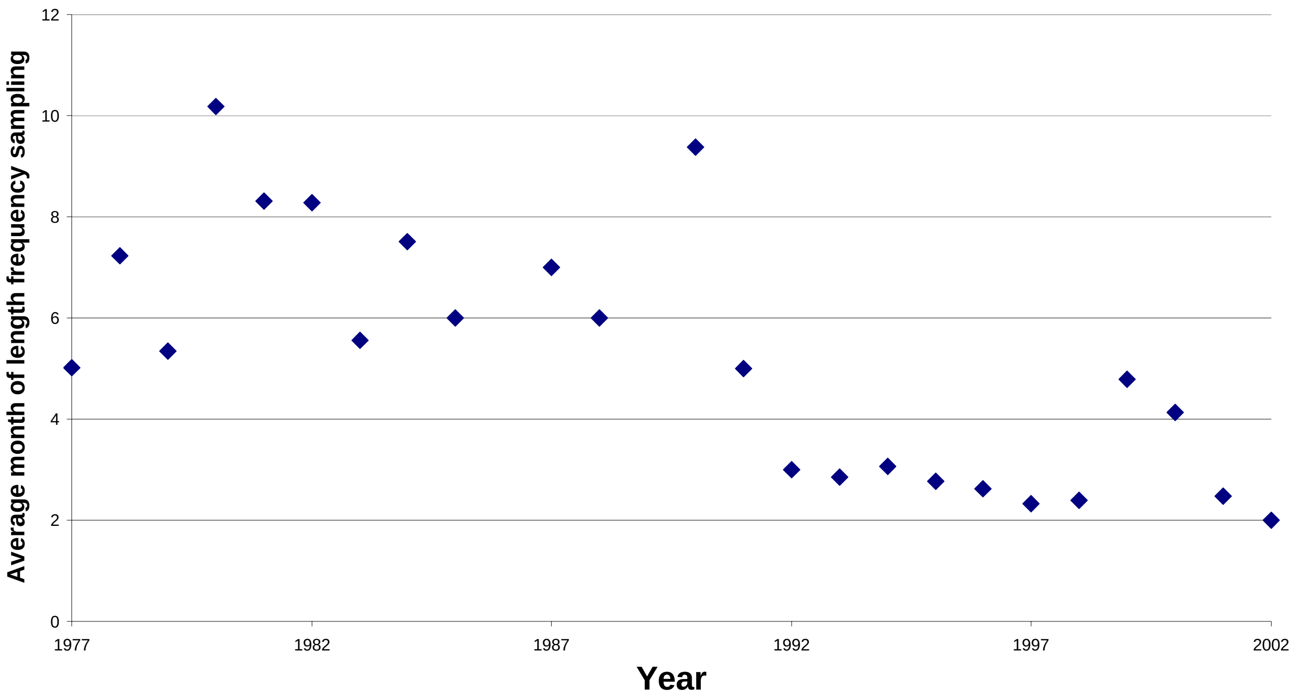


Figure 7. Average month of length frequency sampling (where Jan=1, Feb=2, etc.) for pollock in the NRA region showing that sampling during the early period was from later in the year than during the more recent period.

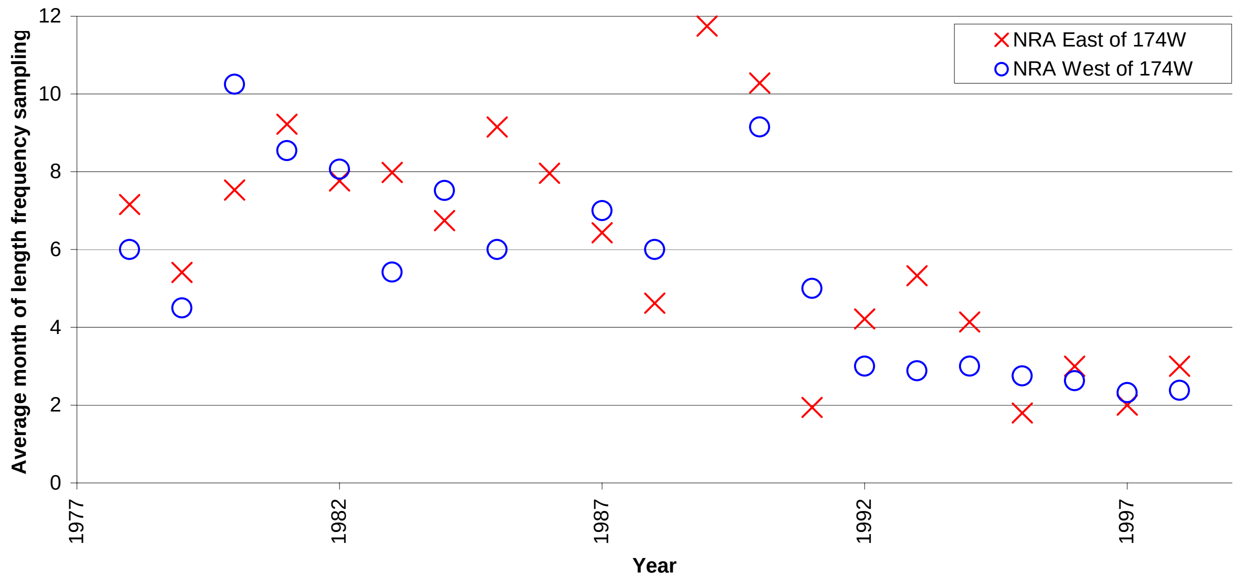


Figure 8. Average month of length frequency sampling (where Jan=1, Feb=2, etc.) for pollock in the NRA region showing that sampling occurred near the same season for both the eastern and western NRA.

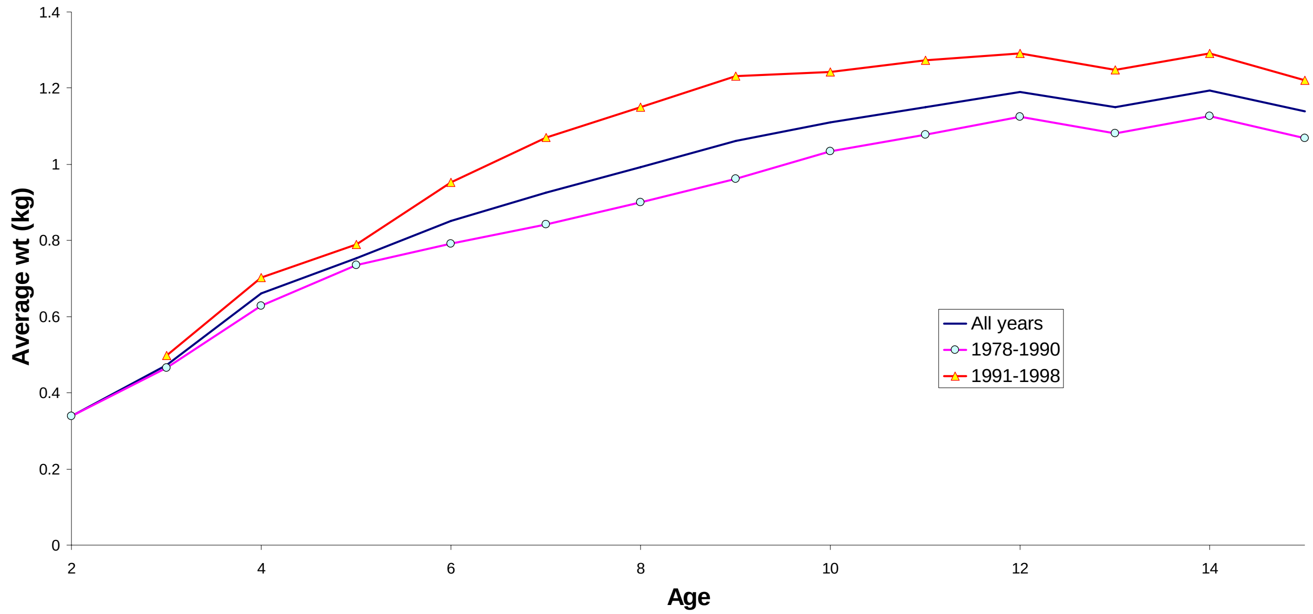


Figure 9. Average weight-at-age for Aleutian Islands pollock for all years combined, 1978-1990, and 1991-1998.

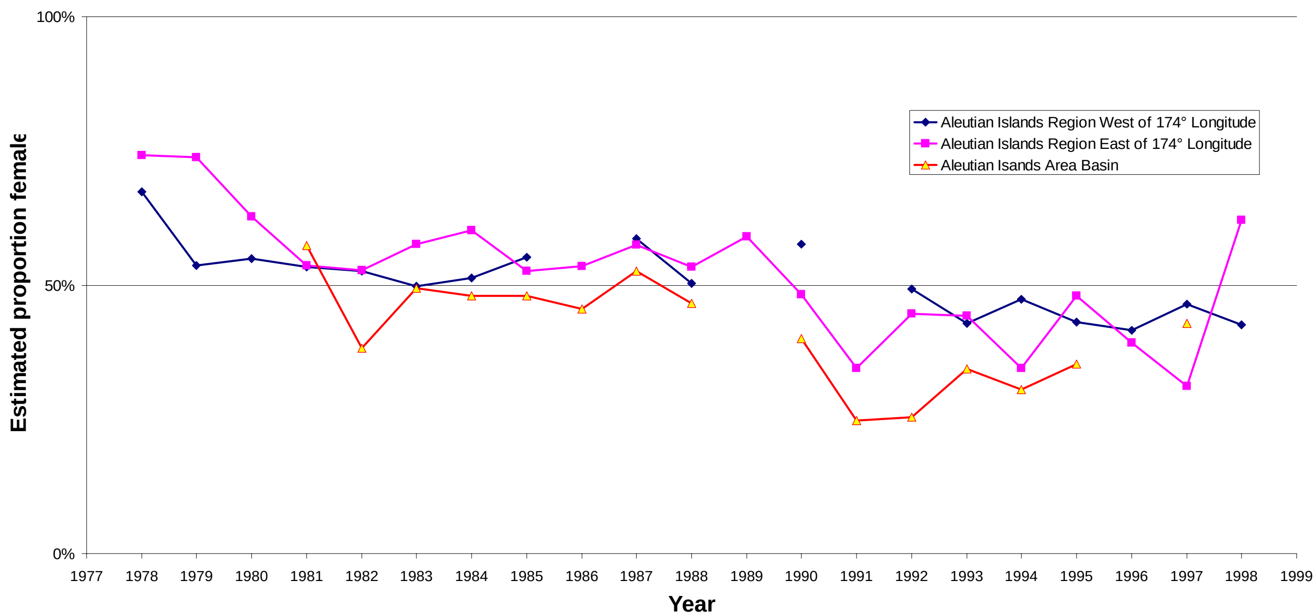


Figure 10. Estimated proportion of female pollock by Aleutian Islands sub-regions, 1977 -1998 based on fishery data.

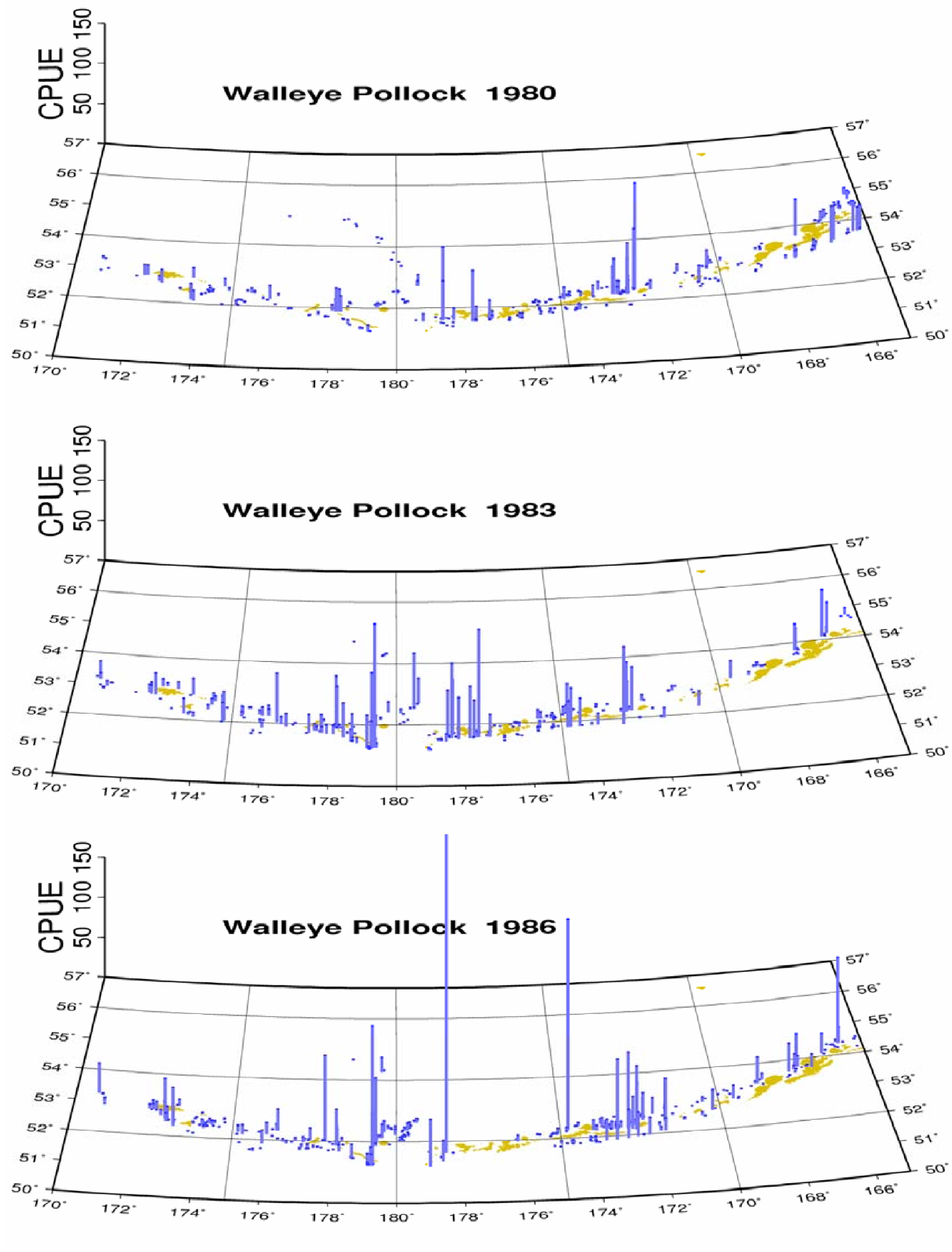


Figure 11. Catch per tow (CPUE) for surveys of pollock in the Aleutian Islands Region and east of 170°W, 1980-2004.

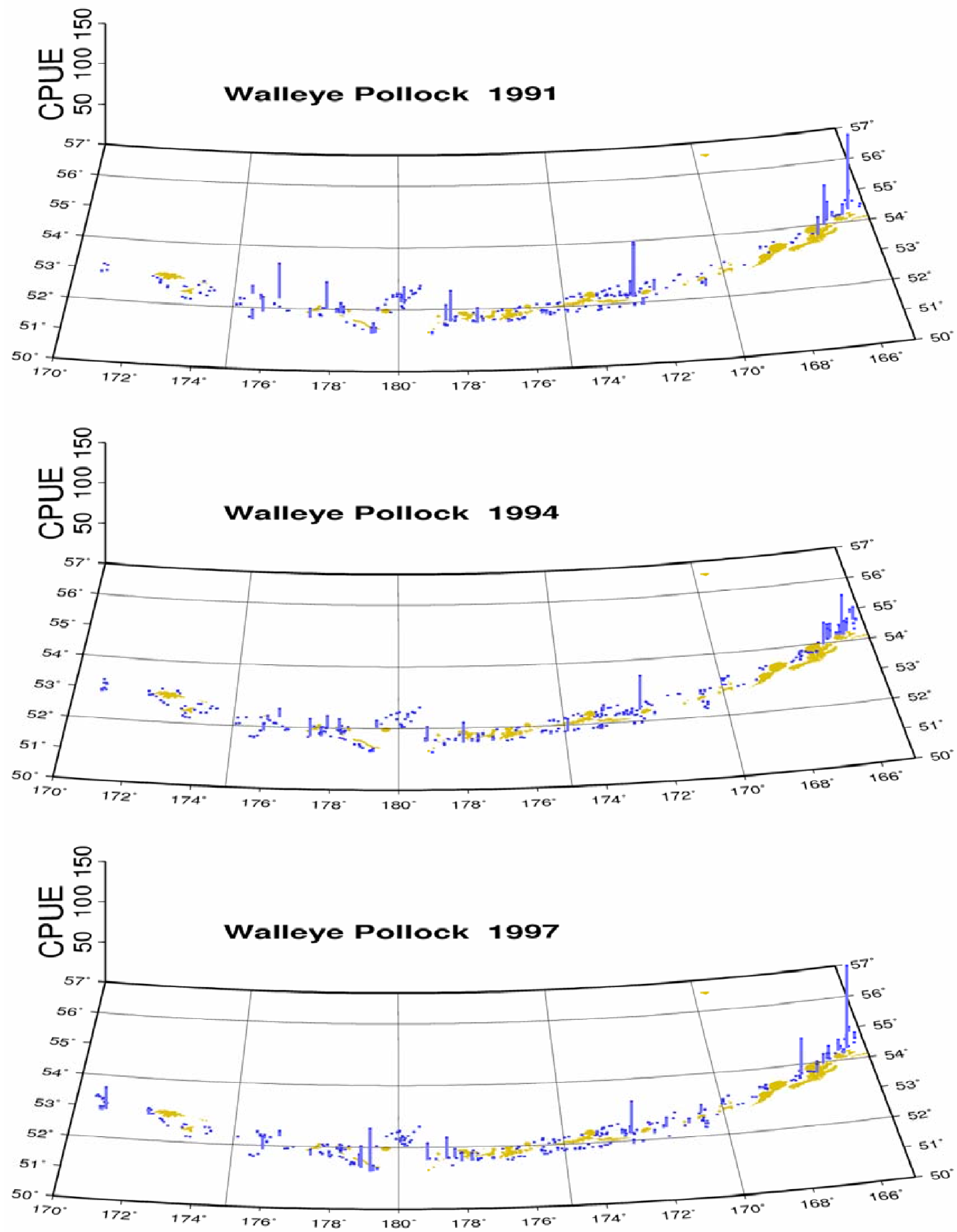


Figure 11. (continued) Catch per tow (CPUE) for surveys of pollock in the Aleutian Islands Region and east of 170°W, 1980-2004.

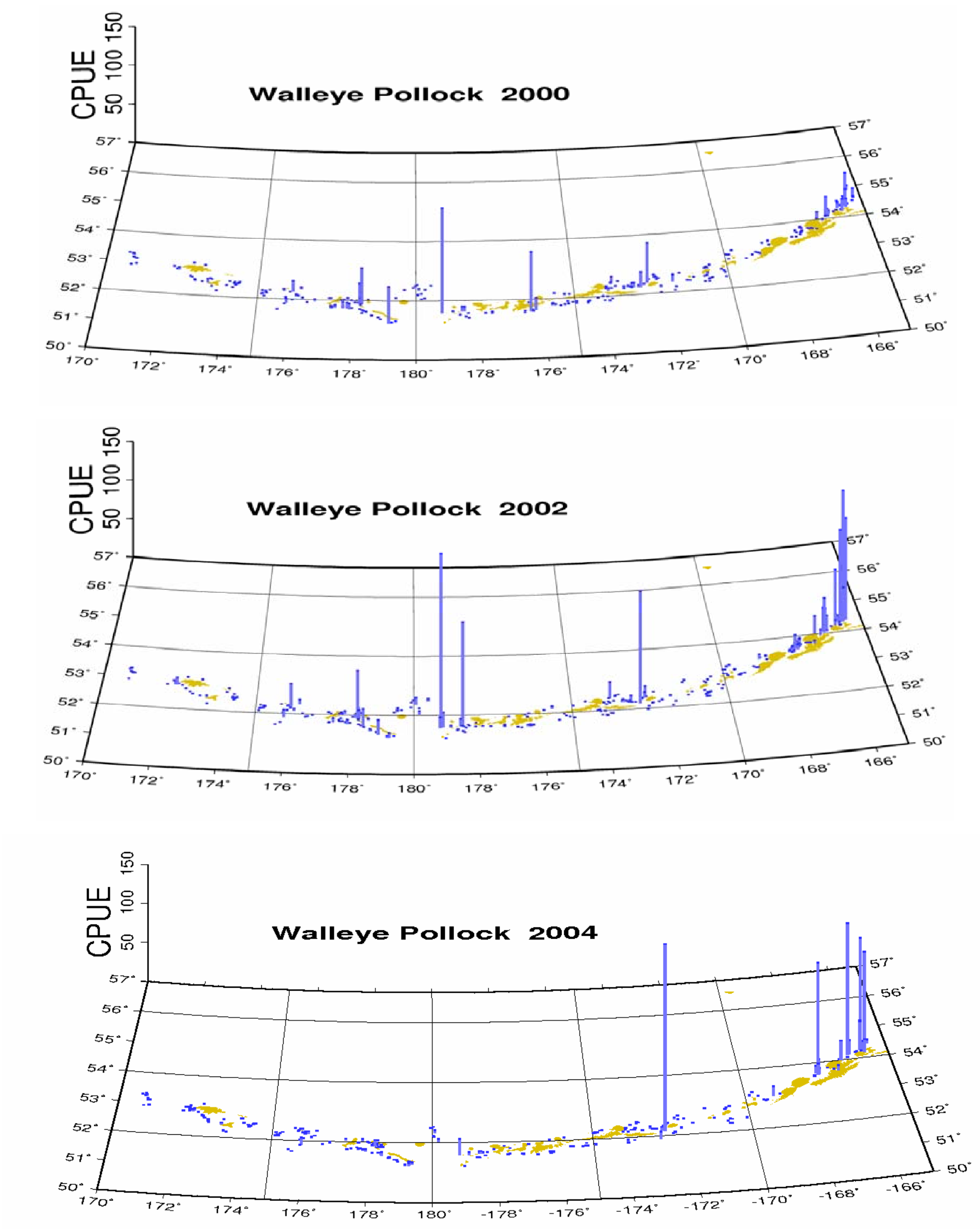


Figure 11. (continued) Catch per tow (CPUE) for surveys of pollock in the Aleutian Islands Region and east of 170°W, 1980-2004.

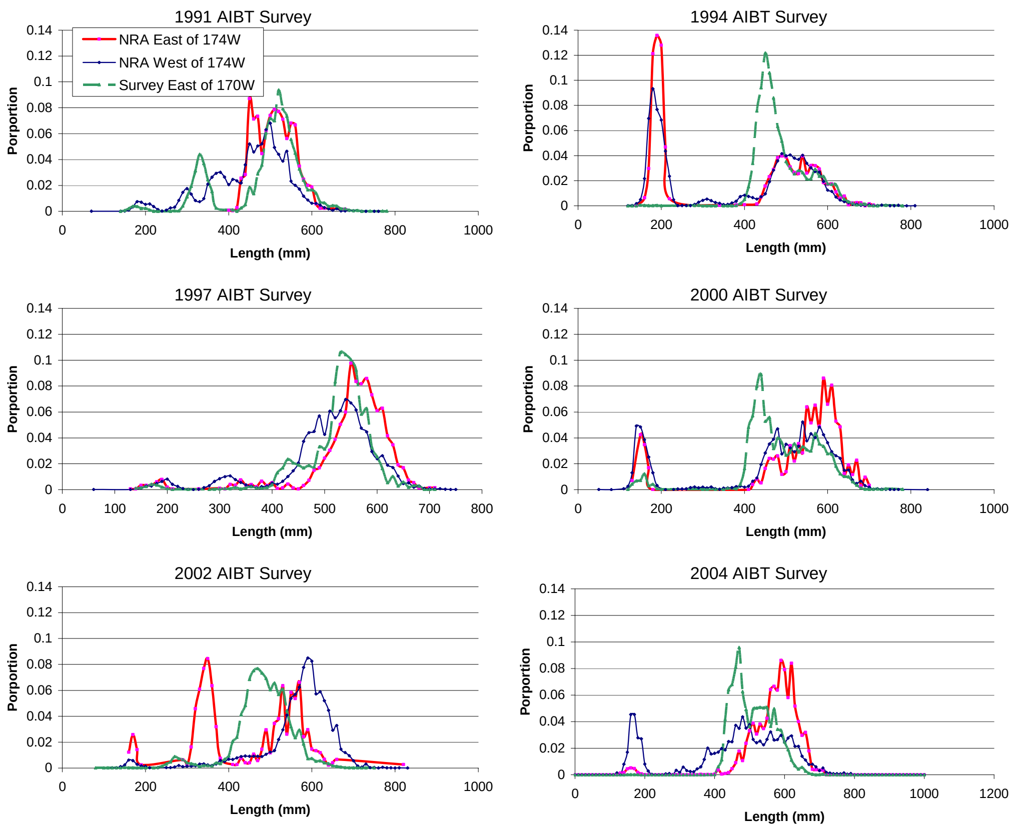


Figure 12. Length-frequency from Aleutian Islands Bottom trawl surveys (AIBT) 1991-2002 showing measurements from the NRA East of 174W, NRA West of 174W, and from the AIBT surveys East of 170W.

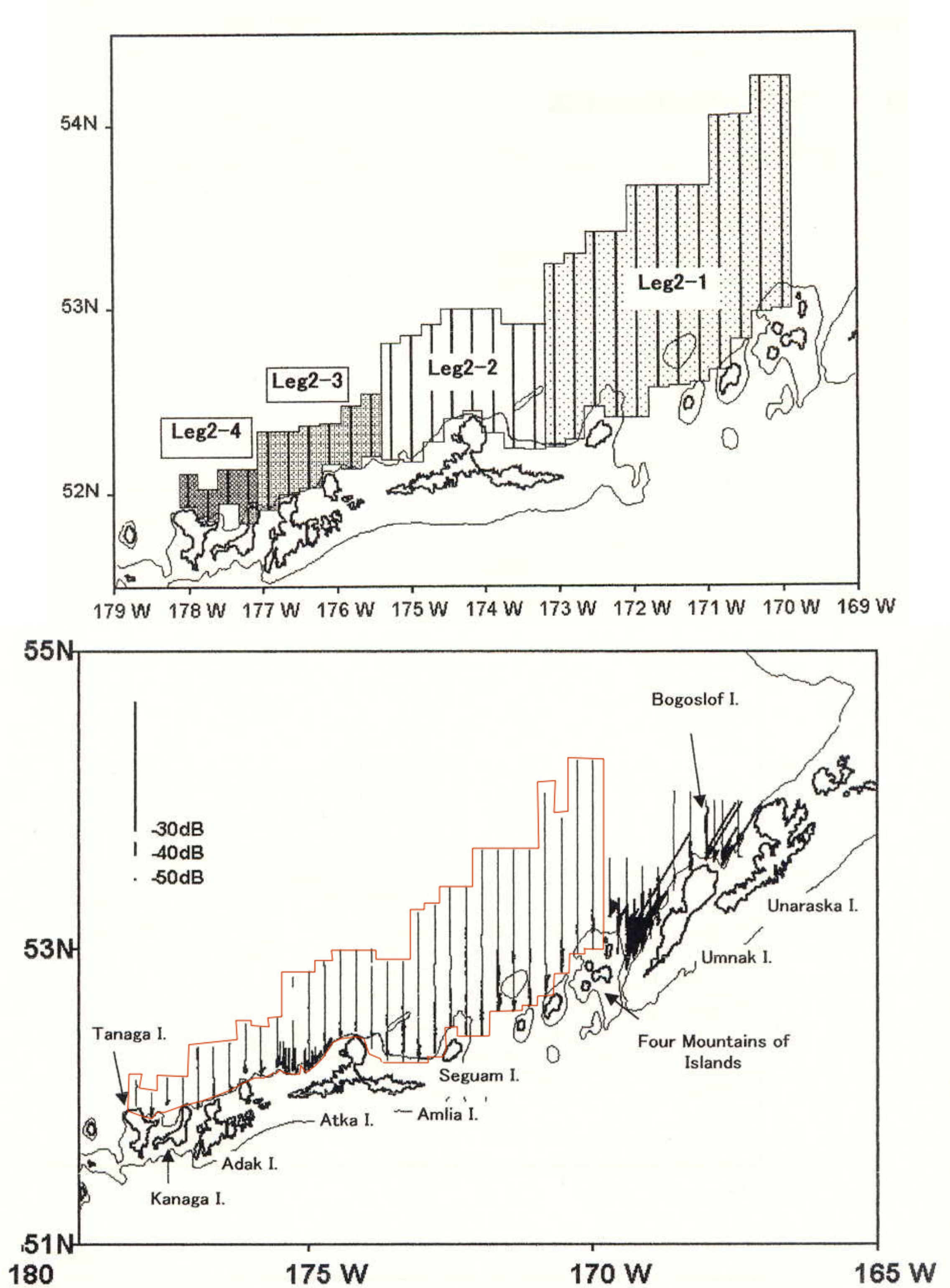
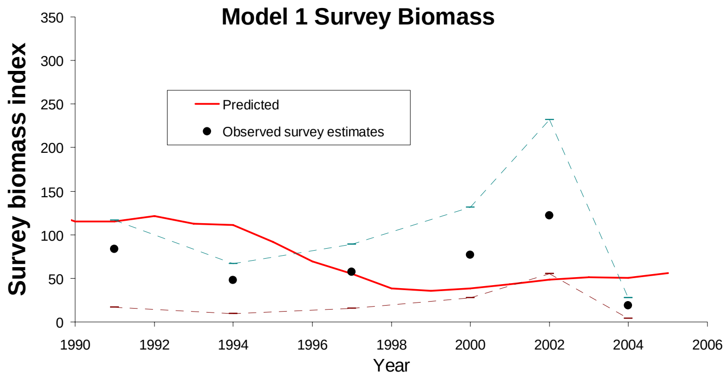


Figure 13. R/V Kaiyo Maru 2002 echo integration-trawl survey (above) strata for leg2 and below observed S_A in both legs. Please note that in the bottom picture the encircled area is leg 2.



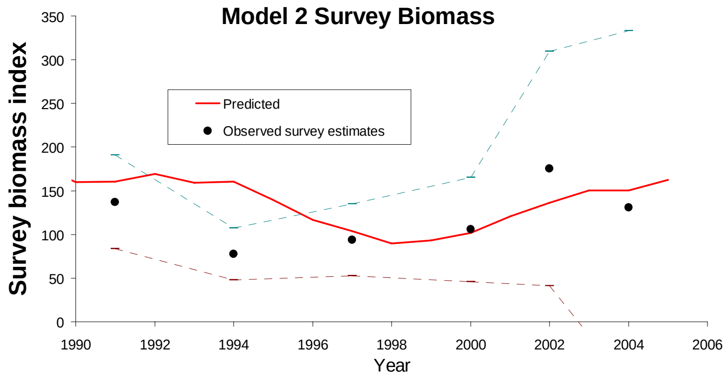


Figure 14. Fit (solid line) to NMFS summer trawl survey (dots) for Model 1 and Model 2. Dashed lines represent upper and lower confidence bounds of survey estimates.

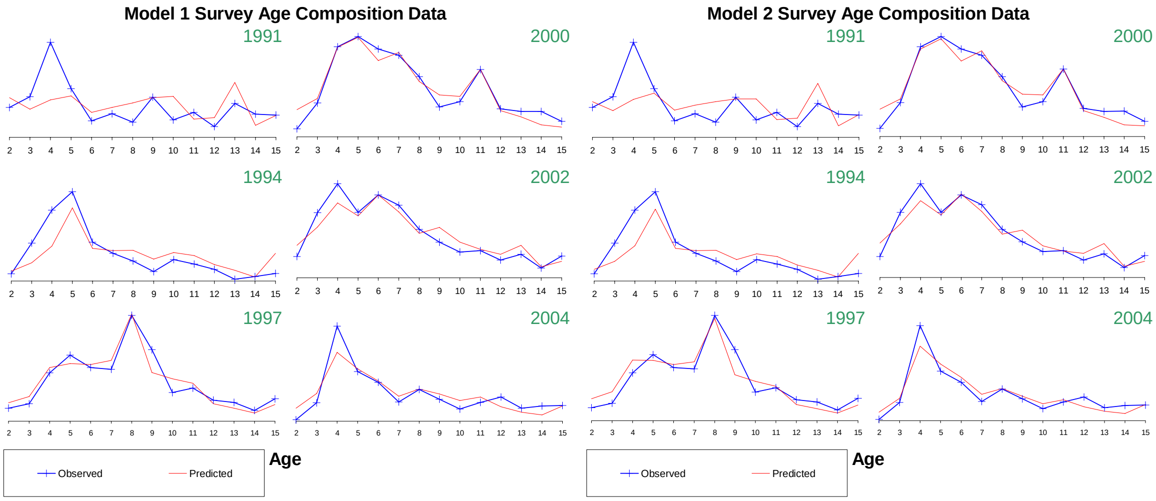


Figure 15. Fits to NMFS summer trawl survey age composition data for Model 1 and Model 2 for Aleutian Islands pollock.

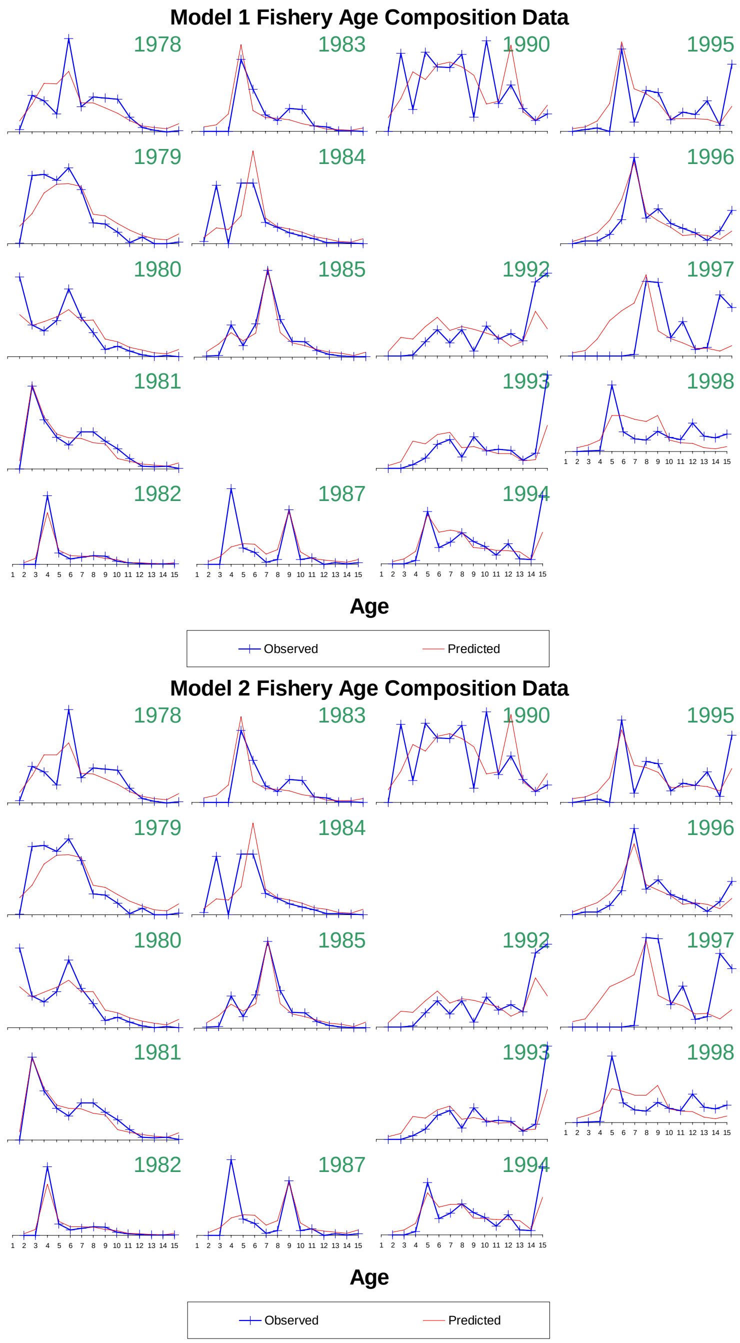


Figure 16. Fit to fishery age composition data for Model 1 (top) and Model 2 (bottom) for Aleutian Islands (NRA) pollock.

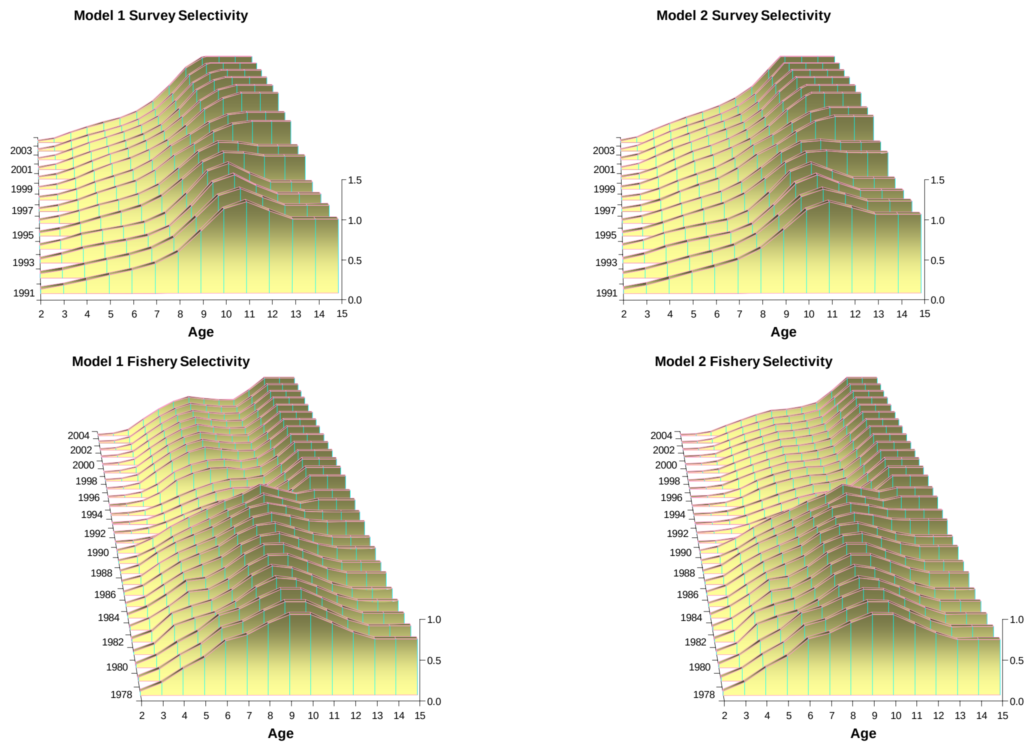


Figure 17. Selectivity estimates for Aleutian Islands pollock for the bottom trawl survey (top) and the fishery (bottom) for Model 1 (left) and Model 2 (right).

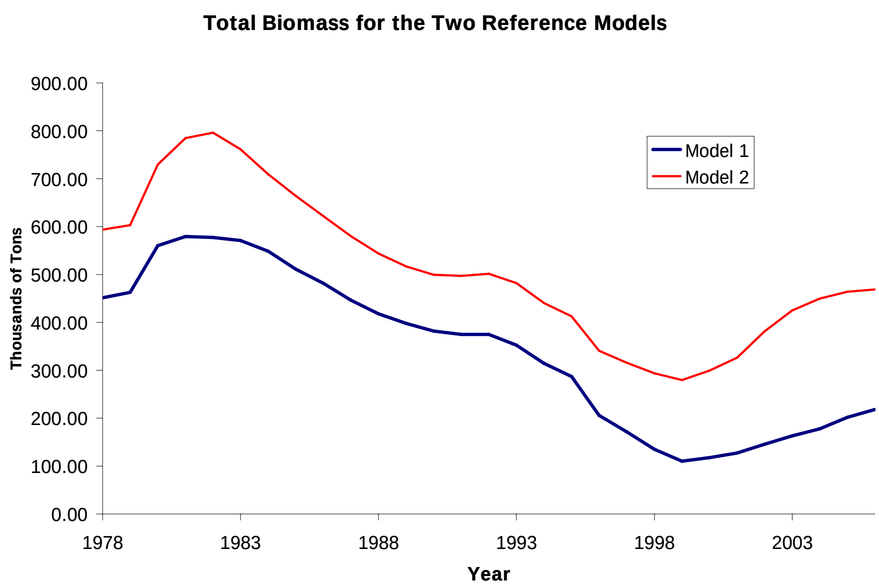


Figure 18. Biomass trajectories under the two alternative model specifications.

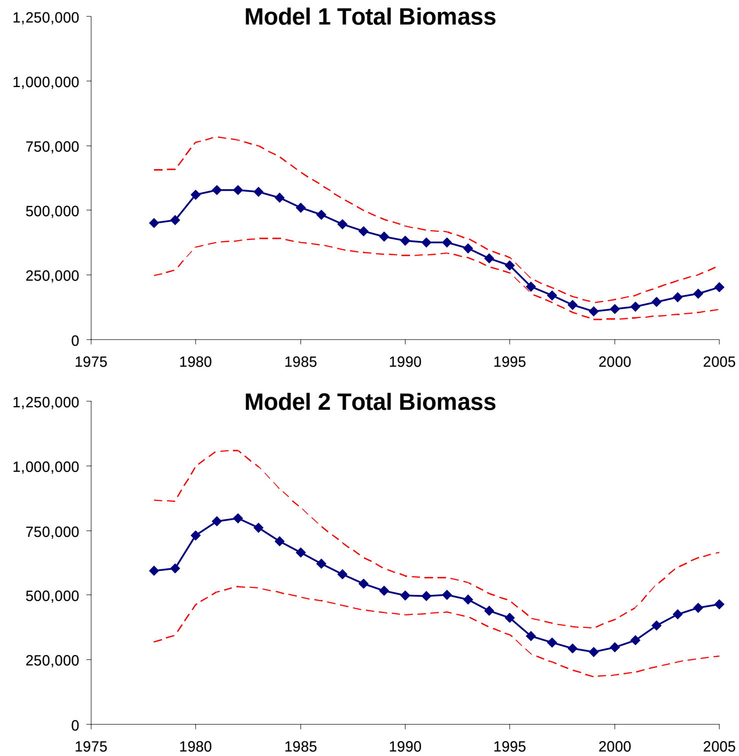


Figure 19. Model1(top) and Model 2 (bottom) estimates of Aleutian Islands pollock age 2+ total biomass (in tons); dashed lines represent approximate upper and lower confidence bounds.

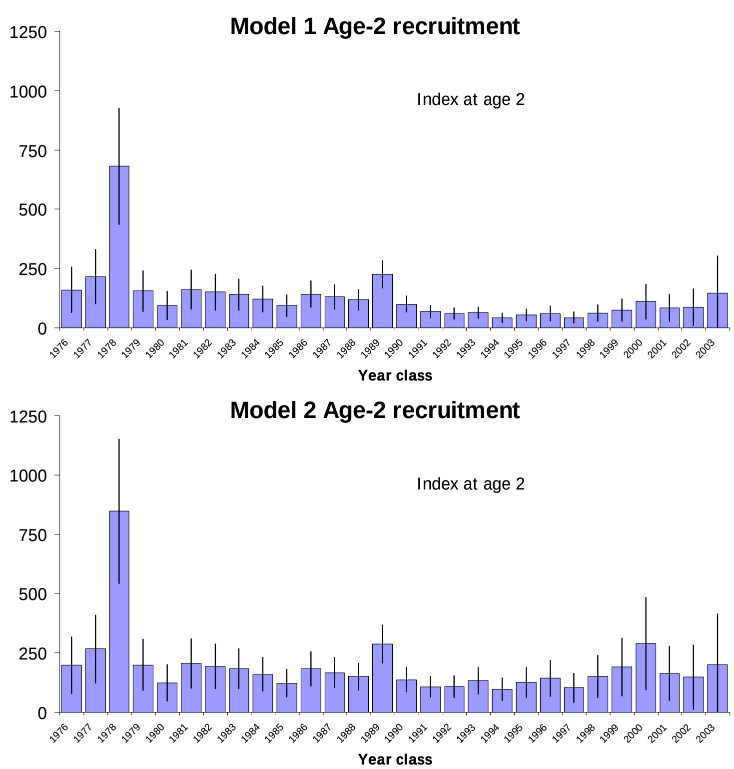


Figure 20. Model 1 and Model 2 estimates of Aleutian Islands (NRA assessment area) pollock year-class estimates; vertical bars represent approximate upper and lower confidence bounds.

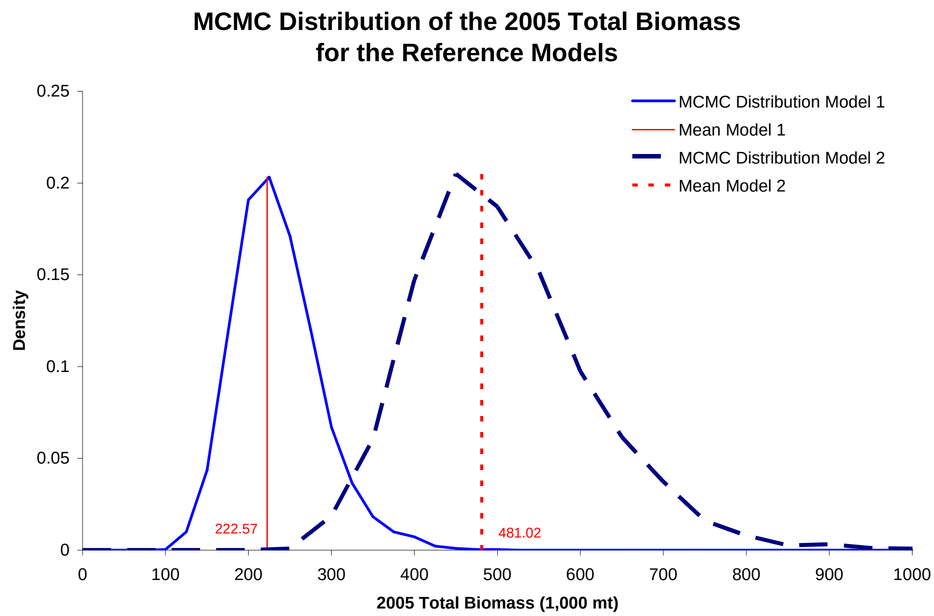


Figure 21 Biomass distributions from MCMC runs of Model 1 and Model 2. Distributions were generated through 1,000,000 MCMC simulations sampled every 200 simulation.

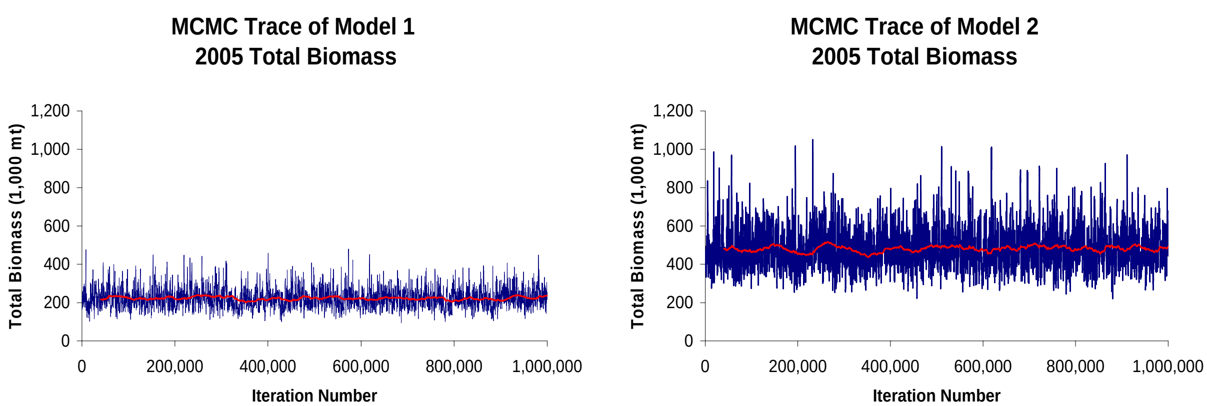


Figure 22 Trace of 2005 total biomass from MCMC simulations generated through 1,000,000 simulations sampled every 200th iteration for the two 6models. The red line is a running mean for every 200th sampled iteration.

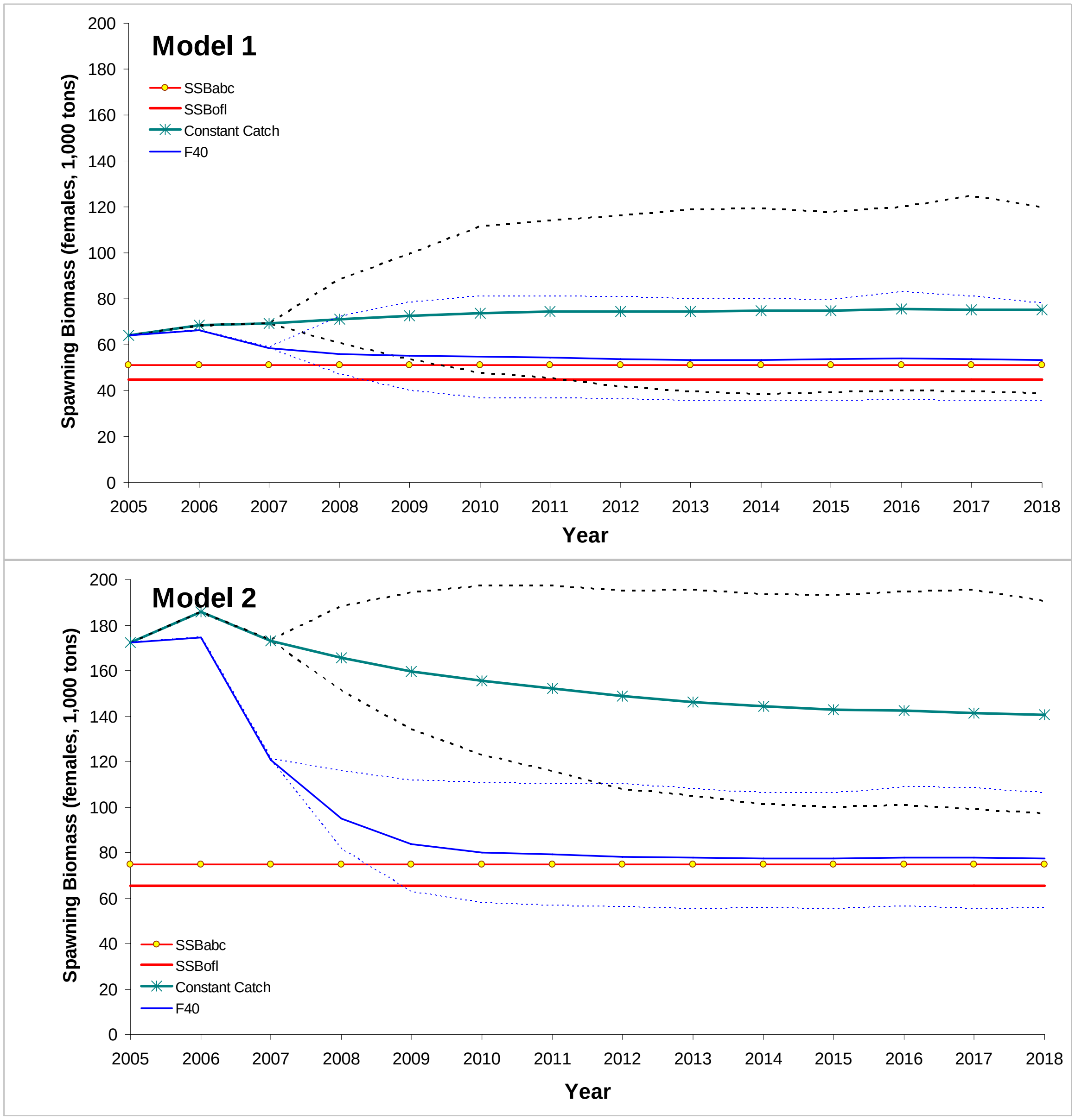


Figure 23 Projected spawning biomass for $F_{40\%}$ and constant catch (19,000 mt) ABC scenarios from Model 1(top) and Model 2 (bottom) with adjusted selectivity-at-age.

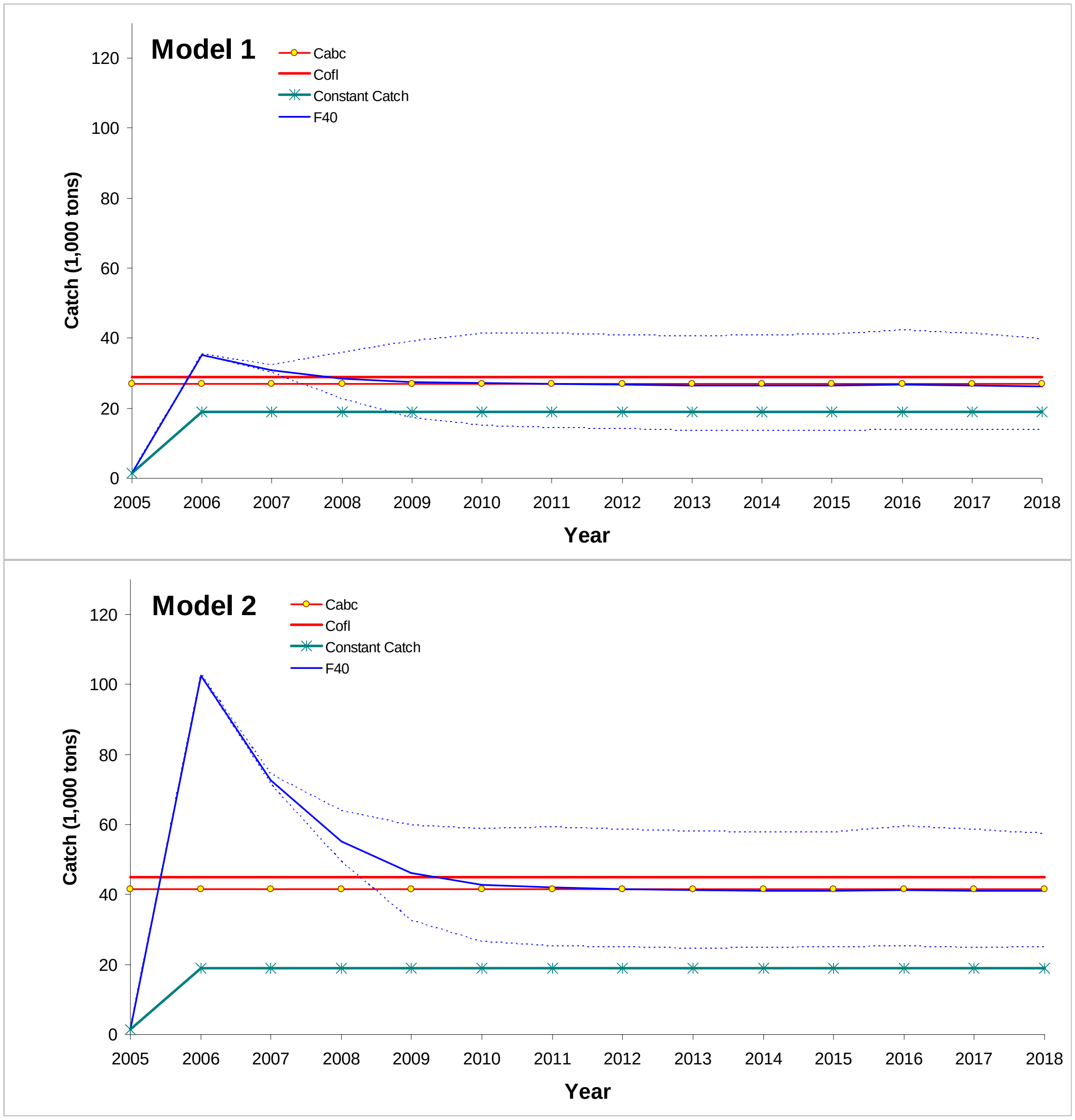


Figure 24 Projected catch for $F_{40\%}$ and constant catch ABC scenarios from Model 1 (top) and Model 2 (bottom) with adjusted selectivity-at- age.

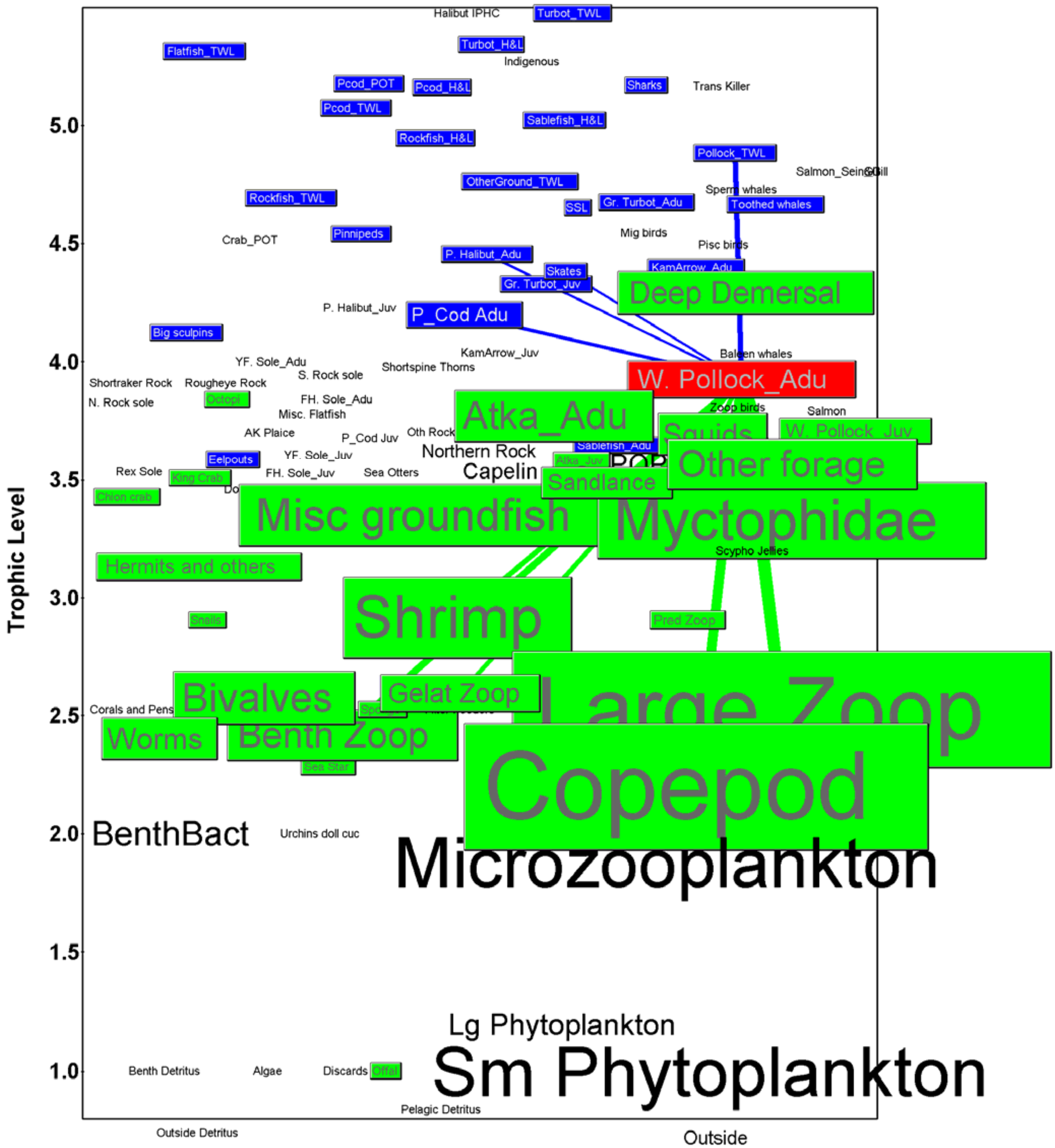


Figure 25 Aleutian Islands ecosystem trophic level map in relation to adult walleye pollock. Everything that consumes pollock is in blue (dark), everything consumed by pollock is in green (light). The size of the box indicates relative abundance in the Aleutian Islands, location on the y-axis indicates trophic level. Figure provided by Sarah Gaichas, AFSC.

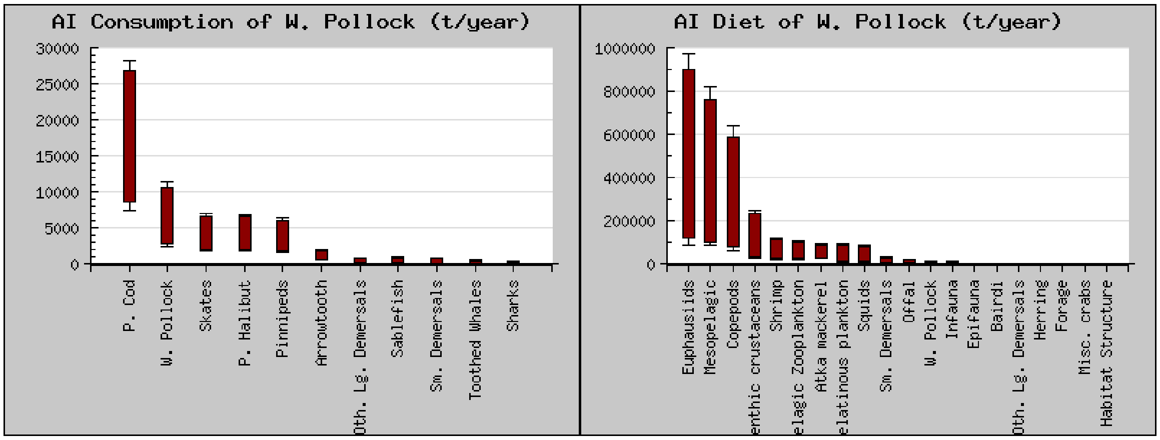


Figure 26 Consumption of (left) and by (right) pollock in the Aleutians Islands from food web model developed for the early to mid-1990’s (Aydin, 2005).

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